



MAINTENANCE OF TRACKAGE

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**DEPARTMENTS OF THE ARMY,
THE NAVY AND THE AIR FORCE**

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THE NAVY, AND THE AIR FORCE
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MAINTENANCE OF TRACKAGE

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Chapter 1.

INTRODUCTION

Section 1. GENERAL

1-1. Purpose

This manual prescribes the policy, criteria, and procedures for inspecting, maintaining, and repairing trackage at military installations. It establishes maintenance standards for railroad and crane trackage systems and provides guidance for the selection, use, and installation of railroad materials and equipment and track components that will perform satisfactorily.

1-2. Scope

This manual is a guide to maintenance of railroad trackage at military installations. Repair, modification, and minor construction procedures are presented within the limitation of maintenance personnel responsibilities. The maintenance standards prescribed have been established to protect Government property, with an economical and effective expenditure of maintenance funds commensurate with the functional requirements and the planned future use of the facilities. The publication furnishes guidance for the maintenance forces in the field who will do the work and is designed for use in the performance of their work.

1-3. Related Publications

The use of the systems and procedures described in this publication, by personnel who have the responsibility for specifications, requisitions, procurement, inspection, storage, issue, application, and safety, should assure uniform, economical, and satisfactory track maintenance and repair. When information in this publication varies from that contained in the latest issue of Federal or Military Specifications, the(se) Specification(s) shall apply. Appendix A lists pertinent regulations, manuals, and other significant publications referenced throughout the text. In case of doubt, advice concerning any procedure may be obtained from the addresses listed below. Also recommendations or suggestions for modification, or additional information and instructions that will improve the publication and motivate its use, are

invited and should be submitted through these channels:

1-3.1. HQDA (DAEN-MPO-B) WASH. DC 20314.

1-3.2. Department of the Navy, Naval Facilities Engineering Command (100), 200 Stovall St., Alexandria, VA 22332, or from its Geographic Engineering Field Division (102).

1-3.3. Department of the Air Force Directorate of Engineering and Services, ATTN: AF/LEE, WASH DC 20330.

1-4. Application

A majority of this manual deals with railroad trackage; however, most information also applies to crane trackage. Where there is a major difference in procedure, trackage will be divided into the following three trackage systems and each discussed separately.

1-4.1. Railroad Trackage. Railroad trackage applies to all track systems used by engines, cars, or locomotive cranes including narrow gage systems.

1-4.2. Ground-Level Crane Trackage. Ground-level crane trackage applies to tracks for all weight-handling equipment that operates on the major working level of an activity. This includes but is not limited to trackage systems for portal, gantry, hammerhead, tower, and the ground-level rail for semi-gantry cranes.

1-4.3. Elevated Crane Trackage. Elevated crane trackage applies to all trackage systems attached or suspended from side walls, columns, buildings, roofs, or separate superstructures. This includes trackage for overhead or bridge cranes, wall cranes, semi-gantry cranes, and floating drydock cranes. NOTE: Rail inspections for monorails, "H" or "I" Beam, and other structural steel shape rail systems and trolley trackage for jib and other hoists are conducted by the crane inspector and/or building inspector.

1-5. Cooperation and Coordination

1-5.1. Intramilitary Functions. Cooperation and coordination of track maintenance activities among

the installation departments concerned should be continuous. Programs of properly planned and executed maintenance operations prevent undesirable interruptions of rail traffic on military installations. Measures for the protection of supplies in storage must be coordinated with the storage service primarily responsible for the care and preservation of stored items. Supply officers, through normal channels, provide standard items of materials and equipment for track maintenance.

1-5.2. Interservice and Interdepartmental Functions. Cooperation and coordination in conducting track maintenance activities are encouraged at all levels of command. Appropriate liaison should be established and maintained between major commands and installations in a geographical area. Cross-service assistance shall be provided as necessary in the interests of economy and maximum utilization of manpower and equipment.

1-6. Army Responsibility

Staff, command, and technical responsibility for maintenance and repair of utility railroad track at Army installations will conform to assignments set forth in AR 420-10 and 420-72. The American Railway Engineering Association (AREA) manual will be consulted on methods, tools, and procedures for railroad maintenance involving problems not covered herein and will be followed when not in conflict with current Army, Navy, or Air Force directives.

1-7. Navy Responsibility

1-7.1. Naval Facilities Engineering Command. The Naval Facilities Engineering Command (NAVFAC) provides technical guidelines and advice for inspection and maintenance of trackage and related accessories. The Commanders and Commanding Officers of NAVFAC's Engineering Field Divisions provide technical assistance in operations and maintenance matters to shore installations.

1-7.2 Commanding Officer. The Commanding Officer at each Naval and Marine Corps shore installation

is responsible for providing safe trackage and an adequate maintenance program. Normally, these responsibilities are delegated to the Public Works Centers or Public Works Departments, as appropriate. Design standards shall be in accordance with NAVFAC DM5. Inspection of trackage systems shall conform to the guidelines established in NAVSEA/NAVFAC Instruction 11230.1 or NAVFAC MO-322.

1-8. Air Force Responsibility

1-8.1. Directives. Policy for the maintenance, repair, and minor construction of railroads and appurtenances is set forth in AFM 85-1 and AFM 86-1, Chapter 2.

1-8.2. Major Command Level. Each major command will:

1-8.2.1. Insure that effective preventive and corrective track maintenance measures are established and accomplished at all installations under its jurisdiction.

1-8.2.2. Provide qualified technical supervision for personnel engaged in these operations.

1-8.2.3. Provide for training of personnel engaged in the maintenance of trackage and appurtenances.

1-8.2.4. Make certain that Base Civil Engineer personnel engaged in direct field supervision of maintenance operations, or those who function independently of direct supervision, are technically competent and thoroughly familiar with the performance of all phases of this activity, as outlined in this publication.

1-8.3. Air Force Installations. The Base Civil Engineer will:

1-8.3.1. Plan, initiate, and supervise the execution of track maintenance.

1-8.3.2. Insure that in-house track maintenance personnel are trained.

1-8.3.3. Investigate the occurrence of and reasons for failures and accidents.

1-8.3.4. Inspect and determine the effectiveness of safety measures.

Section 2. RAILROAD AND CRANE TRACKAGE MAINTENANCE

STANDARDS, POLICIES, AND CRITERIA

1-9. Standards

The standards or criteria contained in this manual have been developed by the Army, Navy, and Air Force with the concurrence and approval of the Assistant Secretary of Defense (MRA&L). Compliance with these standards is mandatory in order that the maintenance of trackage at military installations will be uniform, will adequately support the opera-

tional missions of the installations, and will permit interservice assistance and support, where possible, in the interest of efficiency and economy.

1-10. Policies and Criteria

The extent of repair and maintenance of railroad trackage will be governed by the permanency of the installation, operational requirements, track classification and category, or limiting conditions established by the serving railroads. Work necessary to maintain

base railroads at an equivalent of a Class 2 track as defined in the current Federal Railroad Administration (FRA) Track Safety Standards (Appendix B) will normally satisfy operational needs of military installations. However, safety, efficiency, and economy will be the controlling factors. The FRA Track Safety Standards provide descriptions of tolerances and defects for guidance in overall track inspection. Deviation from the standards in the FRA Track Safety Standards may require immediate corrective action to provide for safe operations over the trackage involved. In general, on heavily used sections of trackage, work planning should start when a deficiency on a section of trackage exceeds one-half (1/2) the allowable deficiency. Selection, installation, inspection, and maintenance of trackage systems shall be in accordance with referenced documents, except where criteria in Chapter 7 provide more stringent or restrictive criteria. In determining the extent and nature of Government maintenance, repairs, and rehabilitation of railroads on land that is held under lease, permit, or easement, the terms of such documents will be taken into account.

1-11. Engineering

The need and accomplishment of major repairs and rehabilitation of existing railroads will be based on the determination of qualified engineers. The services of such technical personnel will be used to assist in the establishment of railroad maintenance programs.

1-12. Specifications

The use of AREA specifications, or those of the railroad(s) serving an installation in lieu of Federal or Military Specifications, may be given consideration when such use would be to the advantage of the Government. Otherwise, the applicable Federal or Military Specification shall take precedence.

1-13. Categories

The term "trackage" includes rails, ties, rail accessories, switches, crossovers, ballast, roadbeds, and support structures. Also included for complete coverage of the trackage system are criteria for the maintenance of slopes, ditches, road crossings, culverts, bridges, trestles, overpasses and underpasses, grade separations, tunnels, signals, snow protection, signs, and markings.

1-13.1. Railroad Trackage System. Railroad trackage systems are divided into six categories according to their principal use.

Category	Service or Use
Running or access	Primary line, industrial and special purpose
Classification yard	Receiving, sorting, and holding
Sidings	Auxiliary (other than for meeting or passing) and house trackage (along or entering a building) and dead storage tracks
Team tracks	Freight transferred directly to highway vehicles
Storage	Hold purposes - low-use spur
Temporary	Generally to facilitate construction

1-13.2. Crane Trackage System. Crane trackage is divided into two major systems: ground level and elevated. Maintenance and inspection procedures are basically the same as those shown for railroad trackage. Operating speeds for cranes shall be initiated and promulgated by activity commanders to meet local safety requirements. Categories may be assigned by type or limiting size of equipment utilizing the trackage system.

1-14. Terms and Engineering Data

A glossary of railroad terms is provided in Appendix C of this manual. Engineering data useful in the maintenance of trackage are presented in Appendix D.

1-15. Active Trackage

The principal tasks to be considered in maintaining active trackage are: renewing ties, ballast, rails, and accessories; raising, realigning, and regrading tracks; oiling and tightening switchpoints and track bolts; cutting vegetation and cleaning ditches; and repairing bridges, trestles, and culverts. Overall maintenance policies and detailed guidance for maintaining these areas are covered in Chapters 2 through 6. Chapter 7 describes procedures for inspecting and reporting trouble areas within trackage systems at military installations. A well-maintained track is shown in Figure 1-1.

1-16. Inactive Trackage.

When trackage is in an inactive status, the maintenance policies will be consistent with the anticipated future mission of the installation and the particular trackage involved.

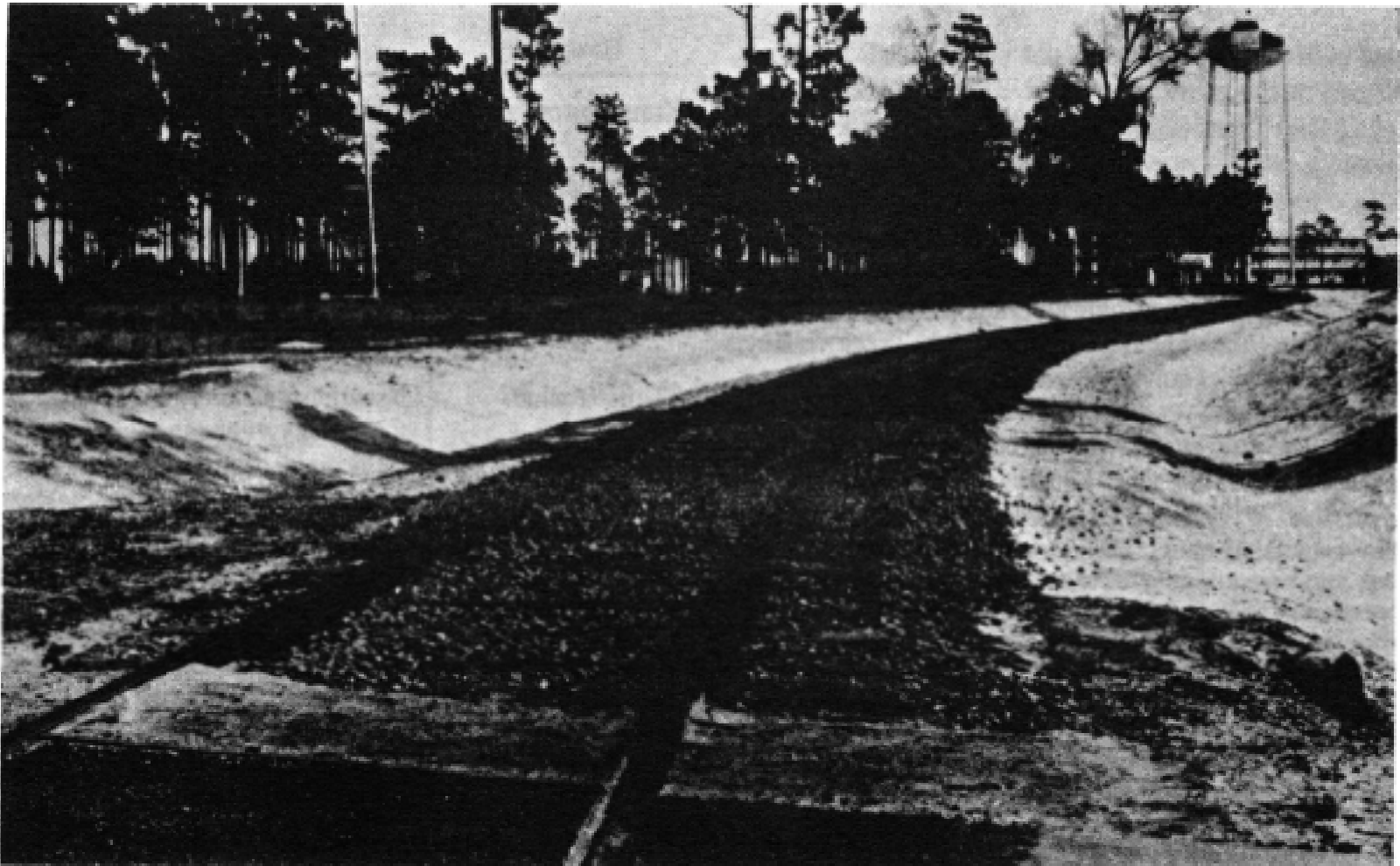


Figure 1-1. Example of well-maintained track.

1-17. Surplus Trackage.

Trackage that is planned for disposal should receive no maintenance except vegetation control. Useful material should be salvaged when such action is in the best interest of the Government.

1-18. Safety

The Occupational Safety and Health Act (OSHA)

guidelines and regulations make certain safety equipment and procedures mandatory.. Safety precautions and safe maintenance practices are covered in detail in the following publications:

1-18.1. ARMY — EM 385-1-1.

1-18.2 NAVY — NAVMAT P-5100

1-18.3. Air Force — AFM 127-101

CHAPTER 2. MATERIALS, TOOLS, AND EQUIPMENT

Section 1. MATERIALS

2-1. General

Maintenance and repair of railroad trackage require the use of special materials, tools, and equipment. It is important that personnel responsible for this maintenance be completely familiar with identification and nomenclature for purposes of use and requisitioning.

2-2. Material Nomenclature and Specifications

In requisitioning track materials, it is important that proper details be given to obtain the exact material required. Figures 2-1 through 2-14 illustrate the most common track materials and present specification details required for drawing clear requisitions.

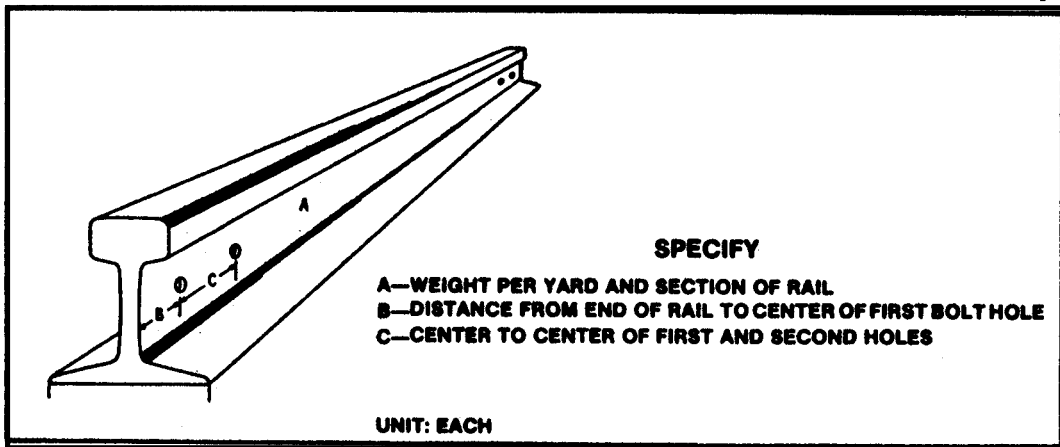


Figure 2-1. Rail details.

2-3. Stocks of Material

Recommended stock quantities for emergency and replacement use are outlined below.

2-3.1. Where deemed appropriate, it is recommended that the following quantities of material be stocked at a convenient location along running tracks or industrial trackage.

2-3.1.1. Two full-length rails of representative weight and section (Figure 2-1).

2-3.1.2. Two short-length rails of representative weight and section.

2-3.1.3. Two pairs of joint bars and compromise joint bars (when appropriate) with bolts and lock washers (Figures 2-2 and 2-3).

2-3.2. Classification/Receiving Yard or Industrial Area. At classification and receiving yard, or other congested areas, stocks should include:

2-3.2.1 One frog of representative number, weight,

and section (Figure 2-4 and Table D-1).

2-3.2.2. One set of switch points (right and left hand) (Figure 2-5 and Table D-1). **NOTE:** Must match existing points in type, section, length, and drilling pattern.

2-3.2.3. Two guardrails (Figure 2-6). Tee rail or one piece manganese. **NOTE:** Guardrails may be straight on ends.

2-3.2.4. One full-length rail.

2-3.3. Central Storage. Recommended stock quantities at a designated central storage area are two full-length rails with track fastenings such as joint bars, bolts, spikes, rail anchors, and tie plates (Figures 2-7 through 2-11) for each mile of track.

2-3.4. Emergency. Minimum standby stocks for emergency use at central storage area are:

2-3.4.1. Switch stand repair parts (complete) (Figure 2-12).

2-3.4.2. Two sets of switch ties (Figure 2-13).

2-3.4.3. One care (30 to 50 tons) of ballast. **NOTE:** This may be deleted at small installations with short trackage.

2-4. Storage of Material.

Stocks of material in the warehouse, section tool house, or in open storage will be properly stored (Figures 2-14 through 2-16).

2-4.1. Rails and Track Accessories. Rails stored at points along a railroad for future use should be segregated by weight and section and stacked in neat piles (Figure 2-14). Store rails above probable high water in case of flooding, and at least 10 feet from the nearest track. Protect accessories from the effects of inclement weather. Always store materials so that they will not interfere with the movement of train

crews or personnel frequenting the area.

2-4.2. Wood and Concrete Ties. Segregate timber cross-ties according to size and type, and store by stacking on high, dry ground. Treated ties may be stacked edge to edge (Figure 2-15). Avoid handling ties with sharp instruments other than tie tongs. Keep ground in the storage area bare of debris or vegetation for at least 2 feet around every stack of ties and clear of vegetation over 6 inches high within 10 feet of any stack; slope the ground so that water will not remain under the stacks or in their immediate vicinity. It is especially important that all decaying wood debris be removed and that fire prevention measures be observed around the storage area. Figure 2-16 shows the proper method of storing concrete ties.

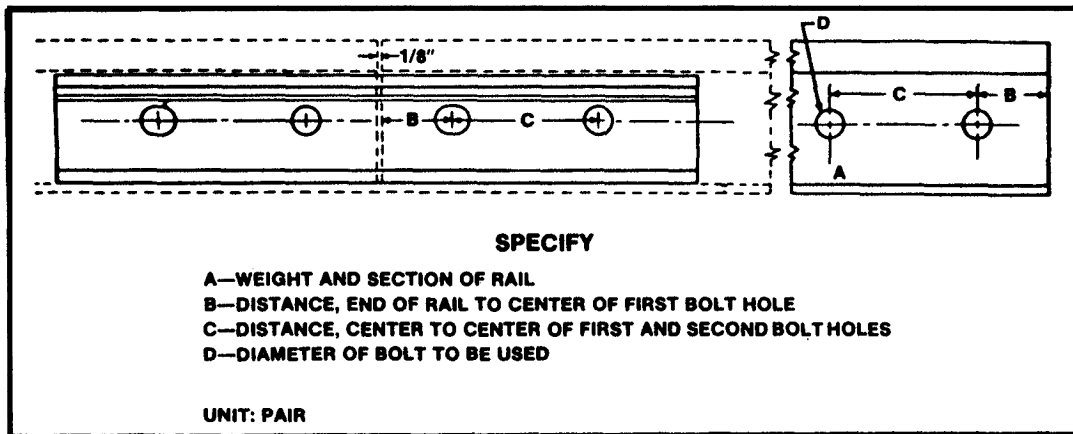


Figure 2-2. Joint bar details.

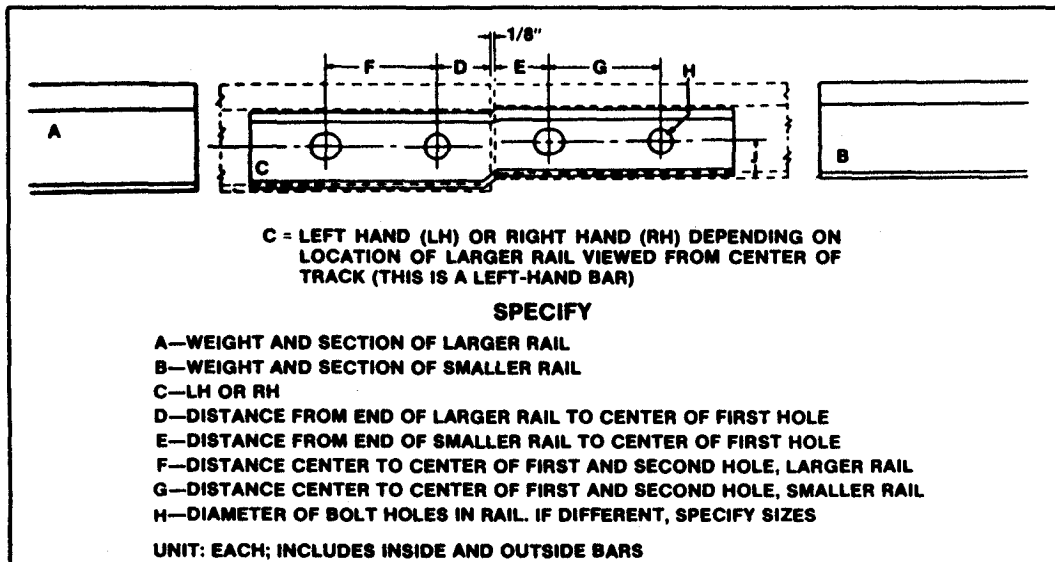


Figure 2-3. Compromise joint details.

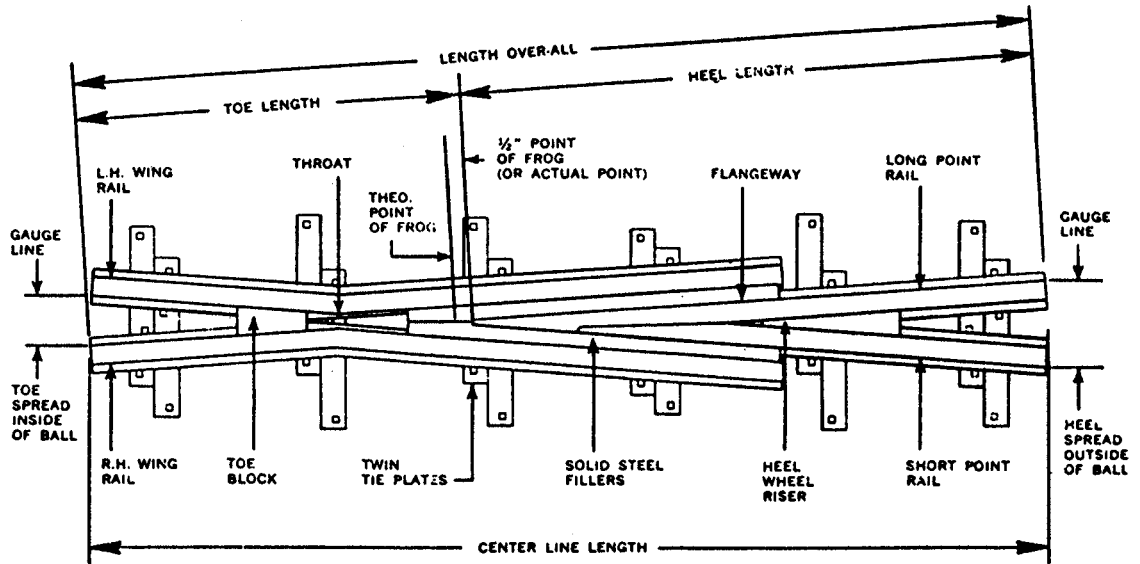


Figure 2-4. Frog details.

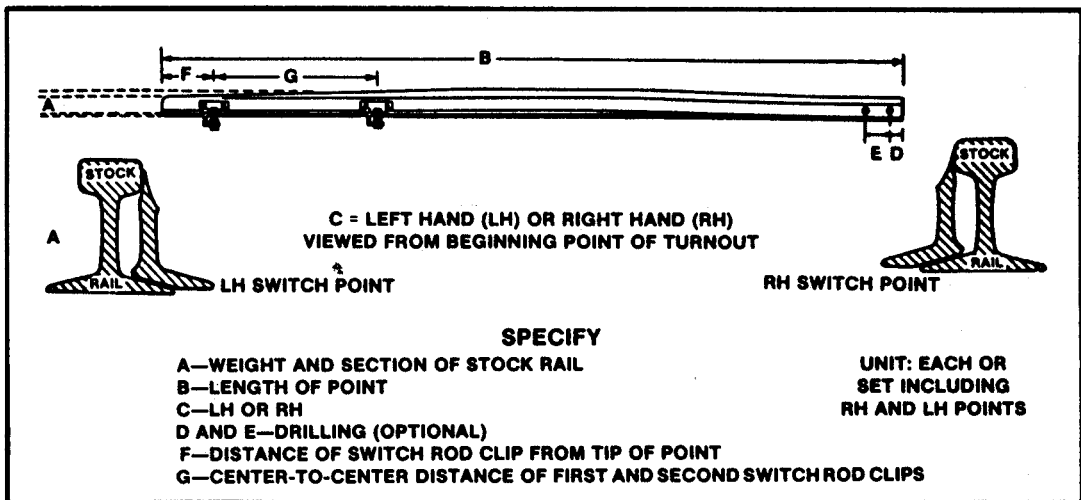


Figure 2-5. Switch point details.

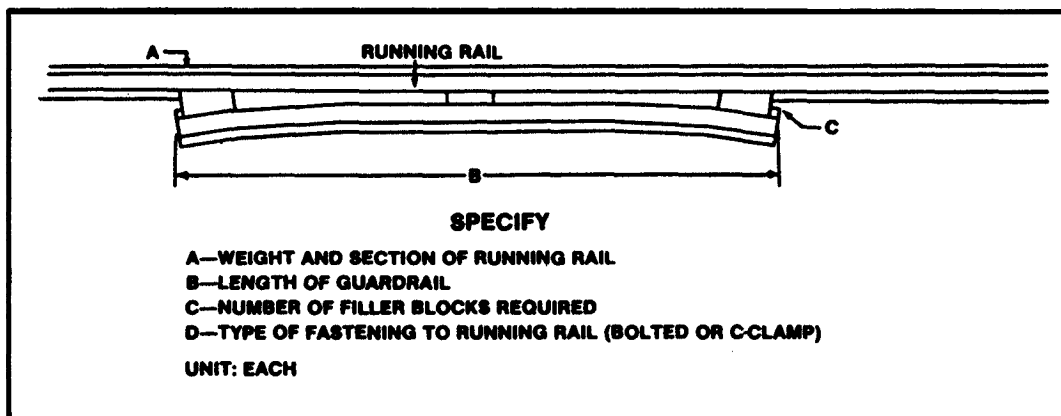


Figure 2-6. Guardrail details

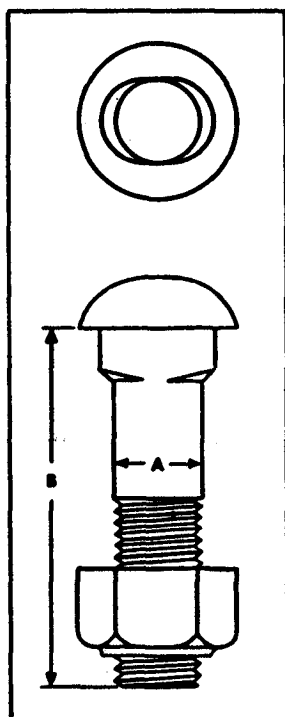


Figure 2-7. Track bolt details.

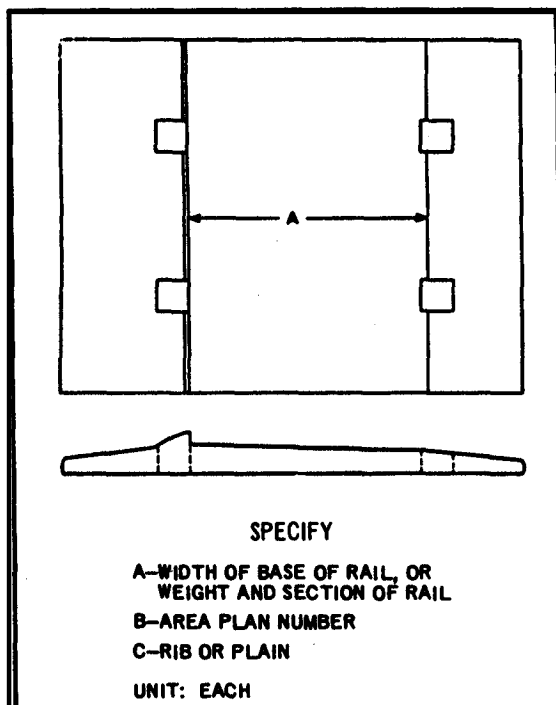


Figure 2-8. Tie plate details.

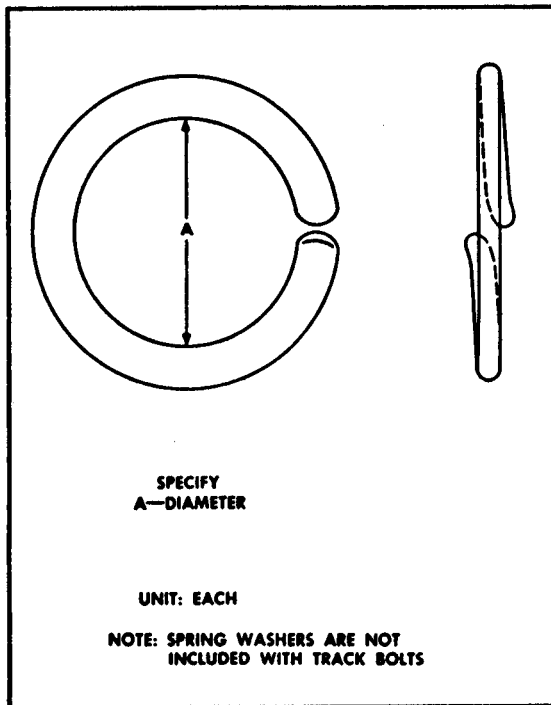


Figure 2-9. Spring lock washer details.

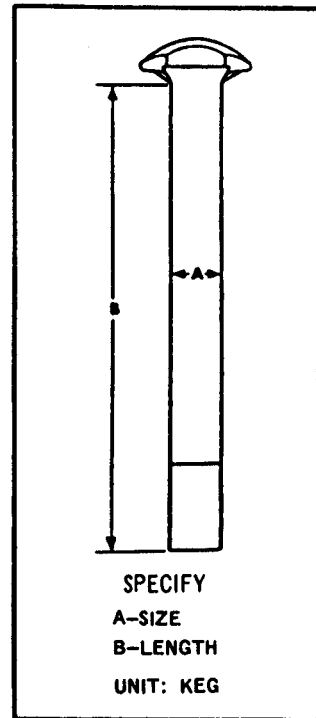


Figure 2-10. Track spike details.

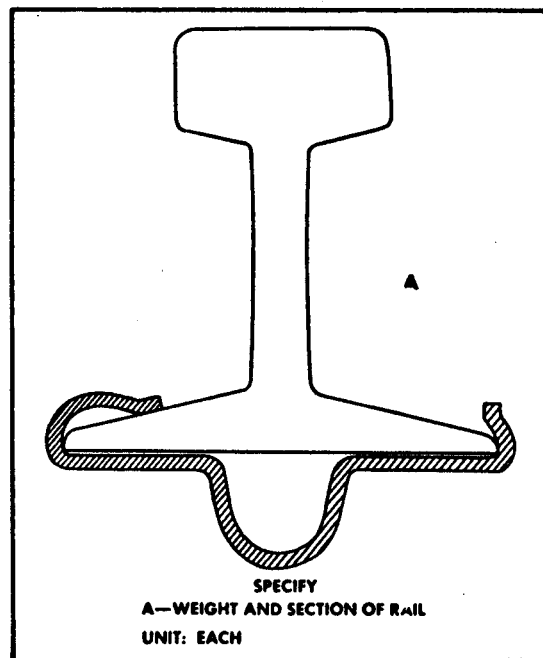


Figure 2-11. Typical rail anchor.

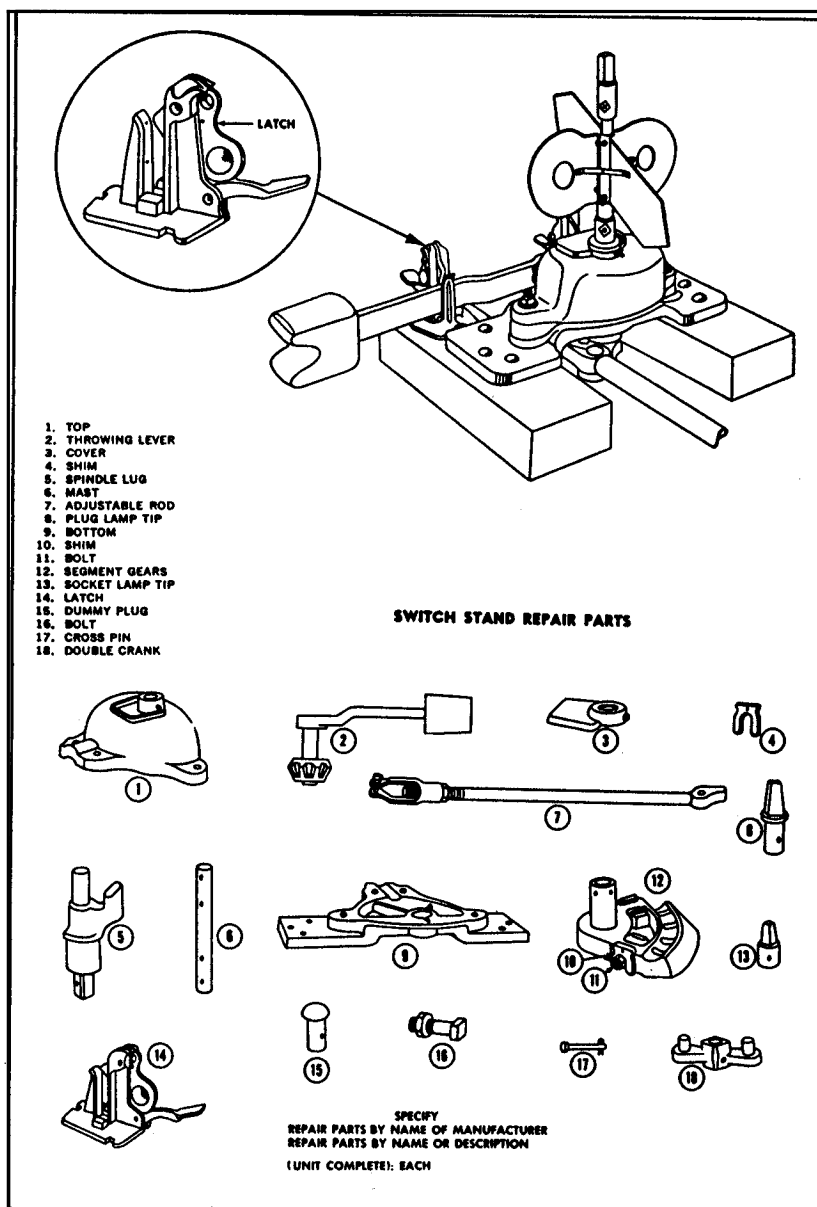


Figure 2-12. Details of switch-stand repair parts. Figure illustrates low stand with parallel throw.

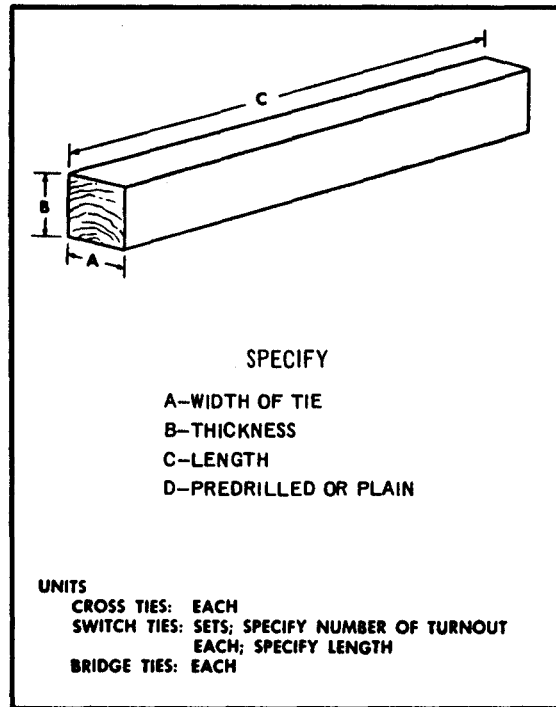


Figure 2-13. Switch, cross, and bridge tie details.

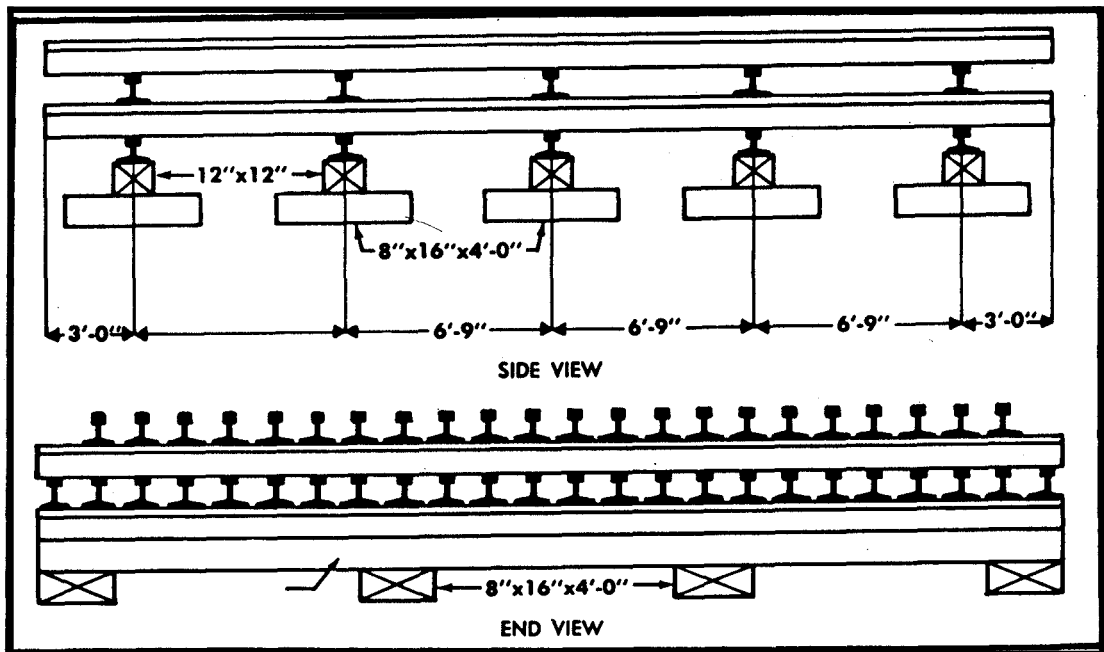


Figure 2-14. Proper method of stacking rails.

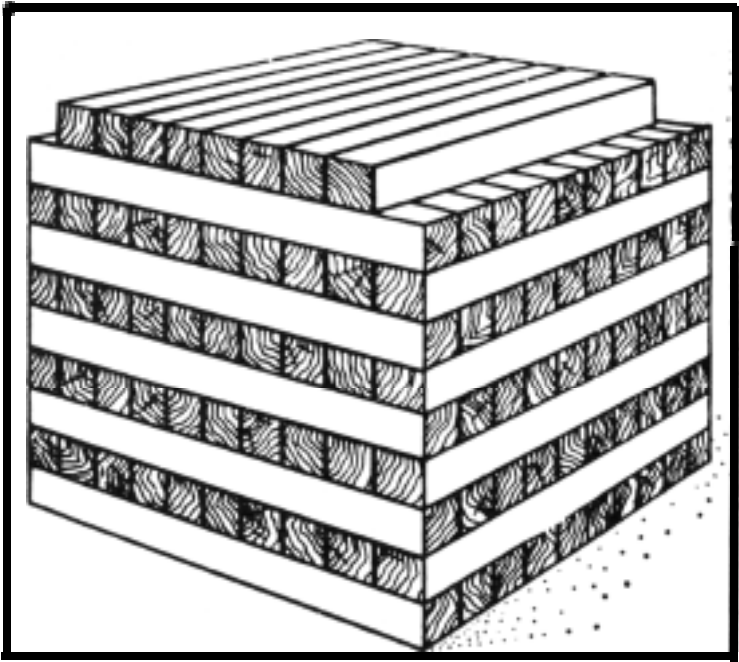


Figure 2-15. Proper method of stacking wood ties.

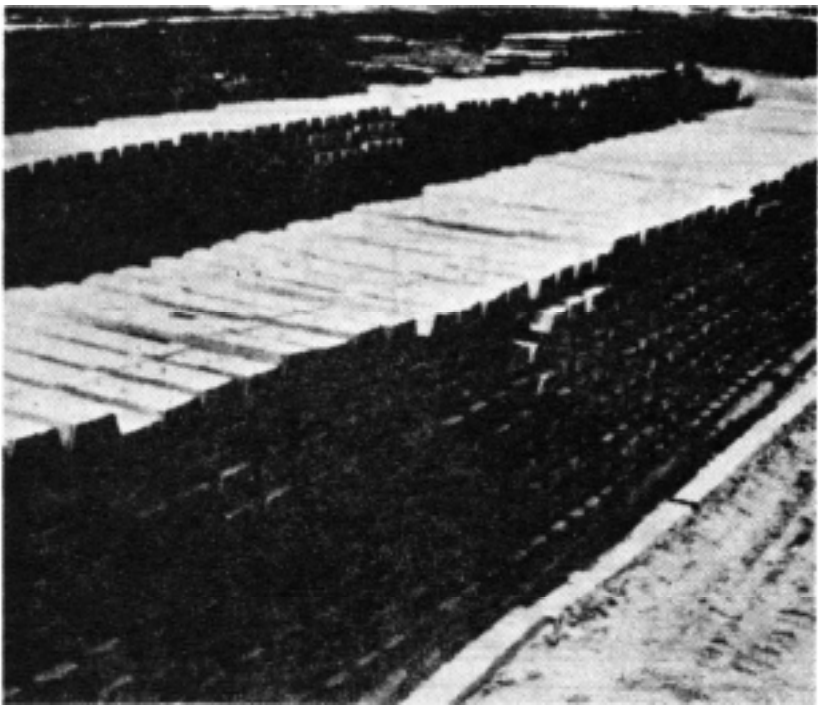


Figure 2-16. Proper method of storing concrete ties.

Section 2. TOOLS AND EQUIPMENT

2-5. Requirements.

Tools and equipment should be provided in quantities consistent with the maintenance to be performed. In specific instances where additional or special tools and equipment are required, they should be procured through normal supply channels. Tools usually employed in track work are shown in Figure 2-17.

2-6. Care and Maintenance.

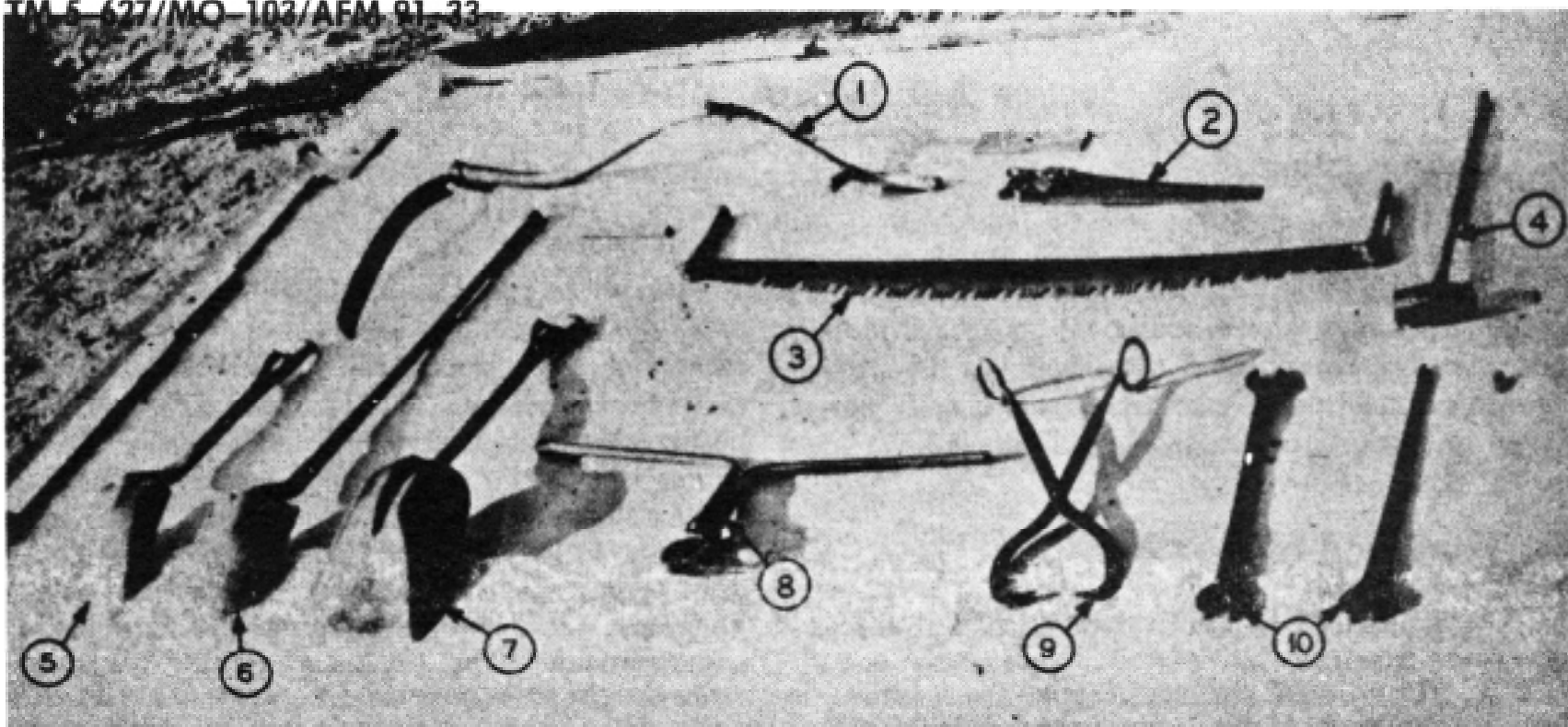
2-6.1. General. Tools and equipment shall be maintained in a constant state of good repair. They shall be kept free of rust and serviceable at all times. Cutting tools such as chipping hammers, drills, chisels, and saws must be kept sharpened and ready for use. Defective or wornout tools and equipment should be repaired or replaced. Personnel handling, using, and storing tools and equipment must do so in an orderly workmanlike manner, adhering to all safety precautions. Railroad maintenance personnel should be constantly aware of rail traffic dangers to life and limb, not only from their own standpoint but from the standpoint of the transportation of personnel and passengers. Tools and equipment must be kept clear of the right-of-way except during actual in-hand use. When loaded on trucks, track cars, or trailers, tools

must be placed so that they will not fall off when bumped or moved (Figure 2-18).

2-6.2. Power Operated Equipment. Where railroad maintenance equipment includes power-operated machinery or specialized machinery such as snow plows, mechanical spreaders, and the like, maintenance shall be carried out as described in individual equipment manuals or in the manufacturer's instructions.

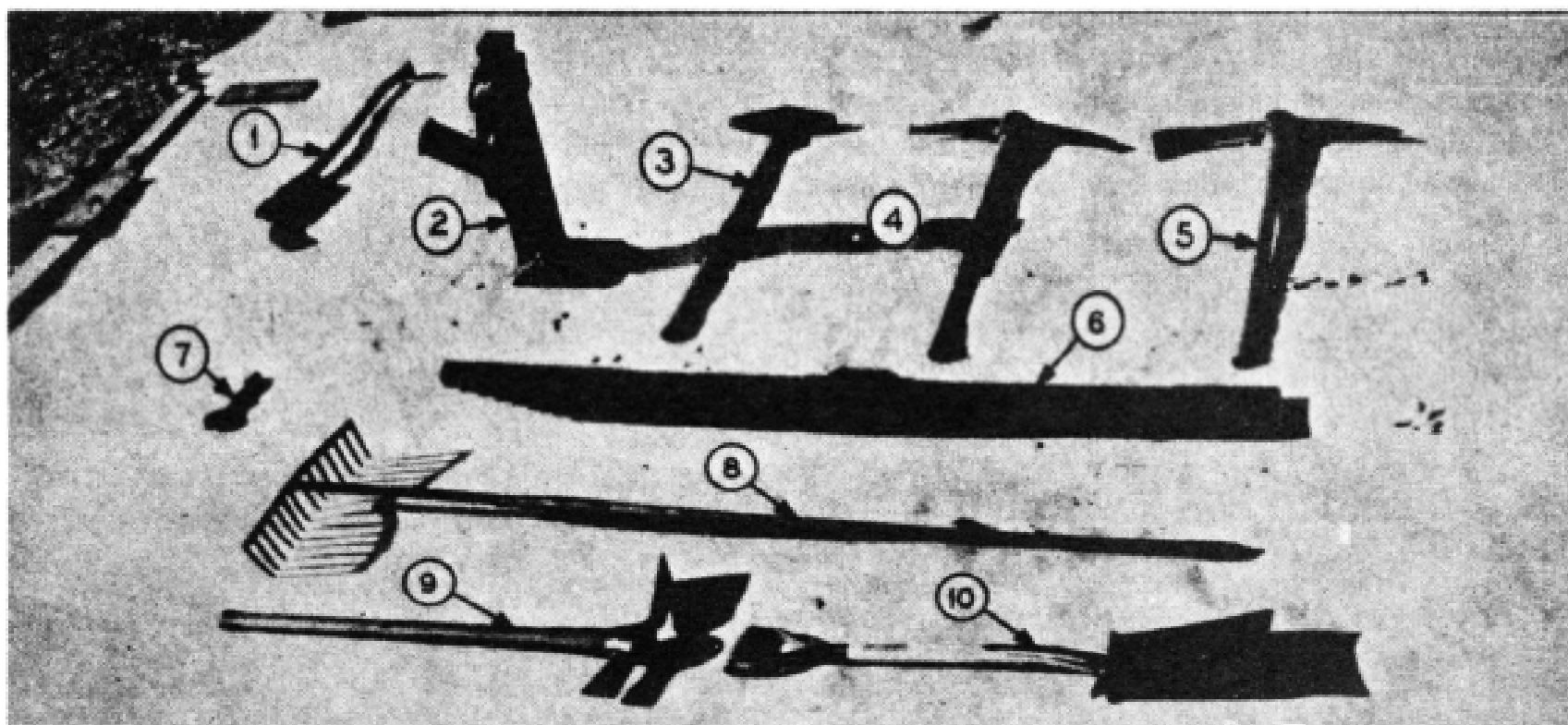
2-6.3. Special Tool and Equipment Maintenance Procedures. In areas where climatic conditions other than temperate exist, special instructions will be given and provisions made for the handling of tools and equipment. This applies to Arctic, tropic, and other severe climatic areas where intense cold, heat, or humidity affect the materials from which tools and equipment are made, as well as handling, storage, replacement, and repair. Adjustment shall be made in supplies and stocks to meet the local situation.

2-6.4. Storage. Tools shall be stored neatly in toolhouses when not in use. Small tools are best kept in toolboxes, whereas larger sharp tools, such as bars, picks, and forks, are best stored in racks designed to protect their points and at the same time be safe for personnel moving about the toolhouse. Power tools or machinery shall be housed against weather, and their accessories systematically stored for ready application.



A.

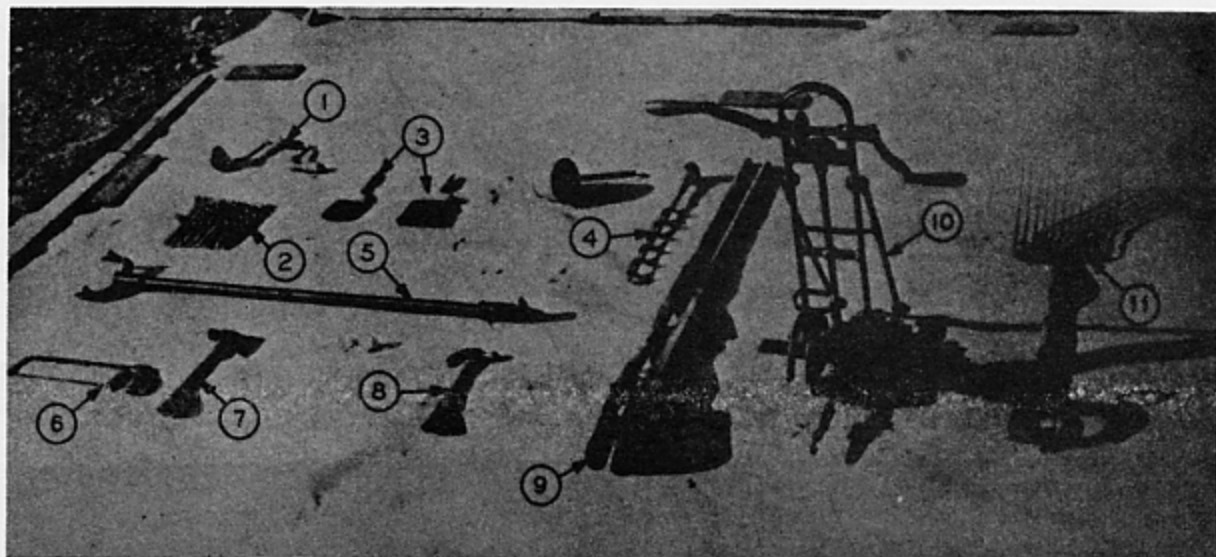
- | | | |
|------------------|---------------------------------------|--------------------|
| 1. Scythe | 5. Short-handled, square point shovel | 7. Scoop |
| 2. Hand saw | | 8. Rail tong |
| 3. Two-man saw | 6. Long-handled, round point shovel | 9. Tie tong |
| 4. Sledge hammer | | 10. Track wrenches |



B.

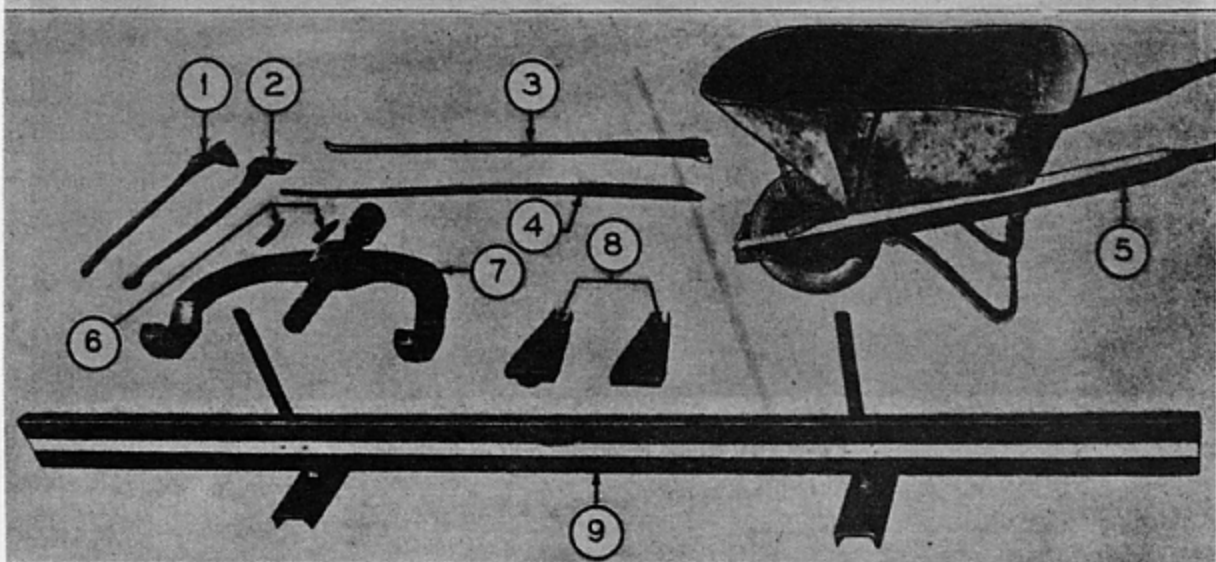
- | | | |
|---------------|-------------------------|------------|
| 1. Brush hook | 4. Pick | 8. Rake |
| 2. Track jack | 5. Tamping pick | 9. Mattock |
| 3. Spike maul | 6. Level board | 10. Spade |
| | 7. Spike-claw extension | |

Figure 2-17. Track tools (Sheet 1 of 2).



C.

- | | | |
|------------------|----------------|---------------------------|
| 1. Drill brace | 5. Track gage | 9. Post-hole digger |
| 2. Wood drills | 6. Hacksaw | 10. Rail-drilling machine |
| 3. Paint brushes | 7. Hatchet | 11. Ballast fork |
| 4. Boring tool | 8. Claw hammer | |



D.

- | | | |
|-------------|-----------------|--------------------|
| 1. Tie adze | 4. Lining bar | 7. Rail bender |
| 2. Ax | 5. Wheelbarrow | 8. Sighting blocks |
| 3. Claw bar | 6. Track drills | 9. Spot board |

Figure 2-17. (Sheet 2 of 2).

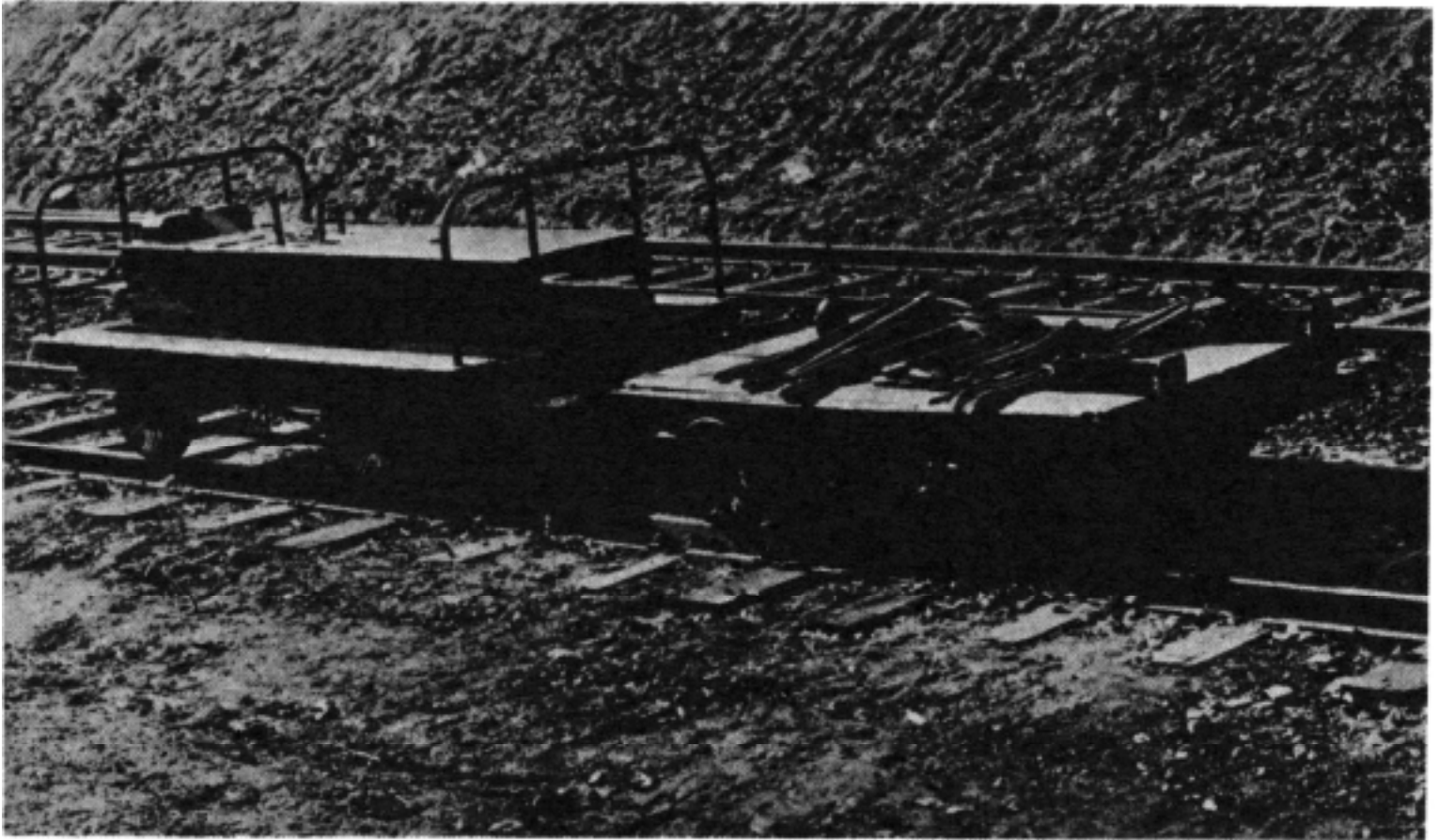


Figure 2-18. *Method of carrying tools on track car.*

CHAPTER 3

TRACK STRUCTURE ELEMENTS

Section 1. GENERAL

3-1. Purpose.

To present methods and procedures for maintenance of track elements in a manner that complies with the policies set forth in Chapter 1.

3-2. Scope.

The criteria for repair, maintenance, and rehabilitation presented in this part of the manual pertain

directly to elements making up the track structure. Many track problems originate with faulty drainage (Chapter 4) or improper original construction. These problems must be solved prior to or during the repair or rehabilitation. Competent engineering assistance may be required to solve them when the determination of the cause of the deficiency is beyond the capability of the maintenance force. Early attention to maintenance problems reduces costly repair and adds to the efficiency of overall operations.

Section 2. BALLAST

3-3. Purpose of Ballast.

Ballast is selected material placed on the roadbed for the purpose of holding the track in line and elevation. It provides uniform support for the track, anchors the track in place, drains water falling onto the roadbed, reduces heaving from frost, and retards the growth of vegetation. Economic factors as well as matching existing work will be considered in determining the type of ballast material for maintenance use.

3-4. Types, Sizes, and Application.

3-4.1. Crushed Stone, Slag, and Gravel. Ballast will have high strength, durability, and permeability. Crushed stone, slag, gravel, and similar materials may be used if they conform to AREA requirements for gradation, wear, and soundness. Coarse gradations, up to 2-1/2-inch maximum size, are preferred.

3-4.2. Pit-Run Gravel. Pit-run gravel is satisfactory for low-use tracks, whereas crushed stone or similar high quality material is required for running track. On weak subgrades, free-draining sand is used as subballast to reduce pumping and the formation of ballast pockets.

3-4.3. Sizes. Tables 3-1 presents maximum and minimum sizes recommended for ballast materials.

Table 3-1. Recommended Ballast Gradation

Type	Maximum Size in.	Minimum Size in.	Percent Fines Allowable by Weight
Crushed rock:			
Traprock	2-1/2	3/4	10
Limestone	2-1/2	3/4	10
Granite	2-1/2	3/4	10
Slag, broken and screened	2-1/2	1	15
Gravel:			
Screened and washed	1-1/2	1/2	10
Screened	1-1/2	1/2	20
Pit-run	Large rocks removed		

3-5. Reconditioning Ballasted Track.

Stone or hard slag ballast shall be cleaned when dirty enough to grow vegetation or when other foreign material restricts proper drainage. Pit-run gravel with fines exceeding 30 percent shall be replaced. Hand methods or mechanical means may be used for reconditioning ballast.

3-5.1 Stone, Slag, or Screened-Gravel Ballast. To recondition ballasted track, the following steps are necessary:

3-5.1.1. Clean ballast shoulder down to subgrade or top of the subballast (Figure 3-1).

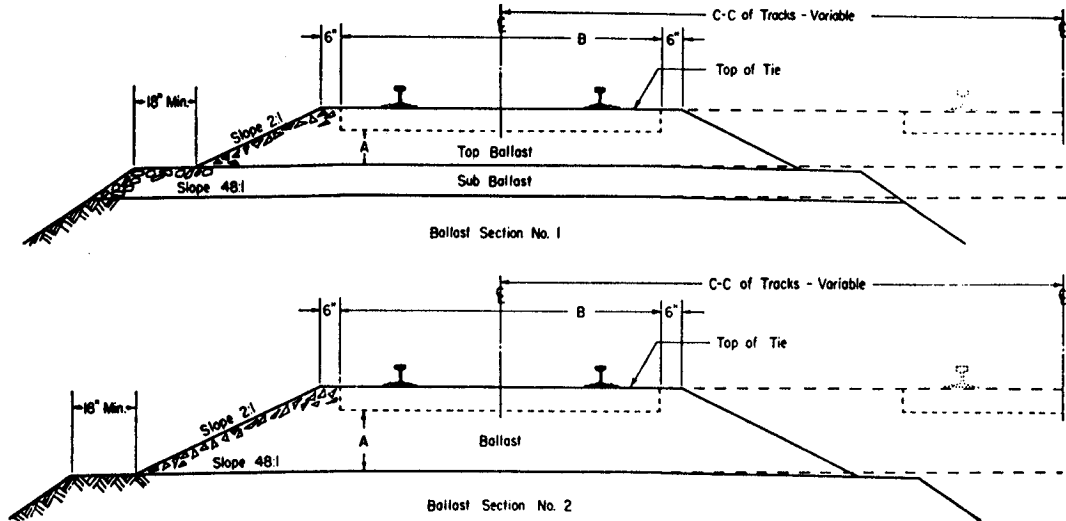


Figure 3-1. AREA ballast sections, single and multiple track, tangent.

3-5.1.2. Clean crib to bottom of ties.

3-5.1.3. Clean space between multiple tracks to bottom of ballast or, at least, to 6 inches below the bottom of the ties.

3-5.1.4. Clean the berm to the bottom of the ballast, preferably not less than 8 inches below the bottom of the ties.

3-5.1.5. Clean cross ditches or drains.

3-5.1.6. Dress subgrade and provide drainage in accordance with minimum slopes shown in Figure 3-2.

3-5.1.7. Clean the ballast removed.

3-5.1.8. Replace cleaned ballast under the track and add enough new ballast to make a standard section. Minimum ballast depth must be maintained at 6 inches below the bottom of crossties.

3-5.1.9. Collect refuse material, and distribute it along slopes of fill.

3-5.2. Pit-Run Ballast. To recondition pit-run ballast, the following steps are necessary:

3-5.2.1. Skeletonize the track by stripping or by raising the track on the old ballast (Figure 3-3).

3-5.2.2. Remove the ballast from outside the track to the original depth of the ties.

3-5.2.3. Dress subgrade and widen cuts or fills wherever necessary. Maintain a 2:1 maximum slope, preferably 3:1 to facilitate maintenance.

3-5.2.4. Clean existing cross drains, or construct new ones; be sure they are deep enough to provide adequate drainage. Never locate cross drains at rail joints.

3-5.2.5. Distribute enough clean ballast to provide for the lift and width desired.

3-5.2.6. Resurface track to uniform grade.

3-5.2.7. Collect refuse material, and place it along slopes of fills.

3-6. Distribution of New Ballast.

Except where the distribution of new ballast is needed for an intended raise out-of-face, the track is surfaced before distribution of new ballast.

3-6.1. Dumping. Ballast is usually unloaded by dumping from hopper cars (Figure 3-4). It is unloaded by having one or more cars opened at a time, allowing the required amount of ballast material to flow out as the train is moved along slowly.

3-6.2. Spreading. The unloaded material should be leveled by means of a ballast plow or spreader. Care must be taken to hold to the established grade set for the new material. Hand methods require special attention to placement of ballast under the full tie length (Figures 3-5 and 3-6).

3-6.3. Tamping. Ballast must be well packed with hand tools or machines, Figures 3-7, 3-8, and 3-9.

3-6.4. Frogs, Guardrails, and Switches. At turn-outs, remove all excess ballast from frogs, guardrails, and the movable parts of switches.

3-6.5. Trimming the Ballast. Ballast should be trimmed to conform to the standard ballast section (Figures 3-1 and 3-2), using an appropriate template. Slopes shown are preferred; however, conditions may require different slopes. The portion of the subgrade outside the ballast line should be left with a full, even surface and the shoulder of an embankment clearly defined and properly dressed to the standard road-

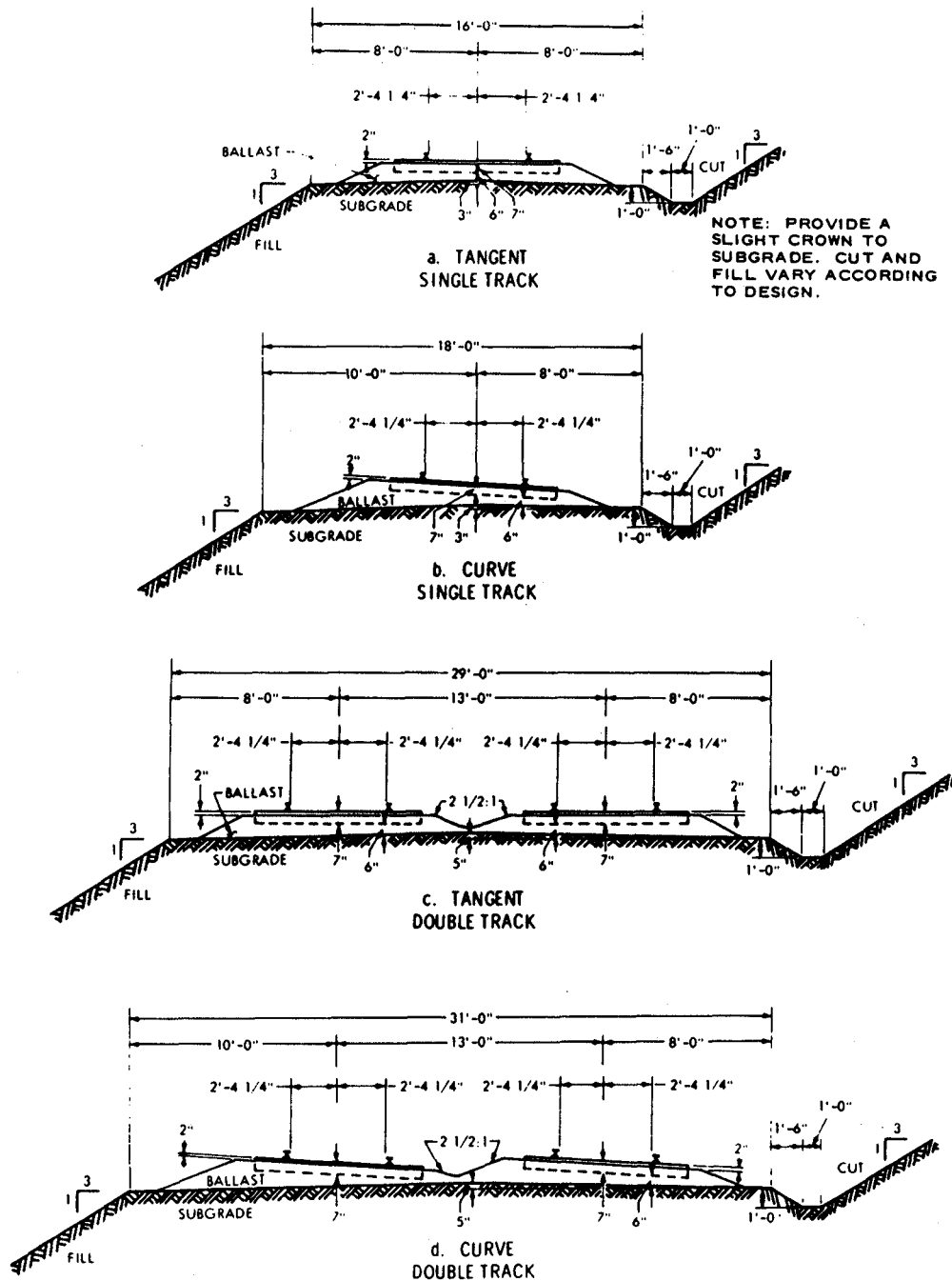


Figure 3-2. Details of standard ballast sections.

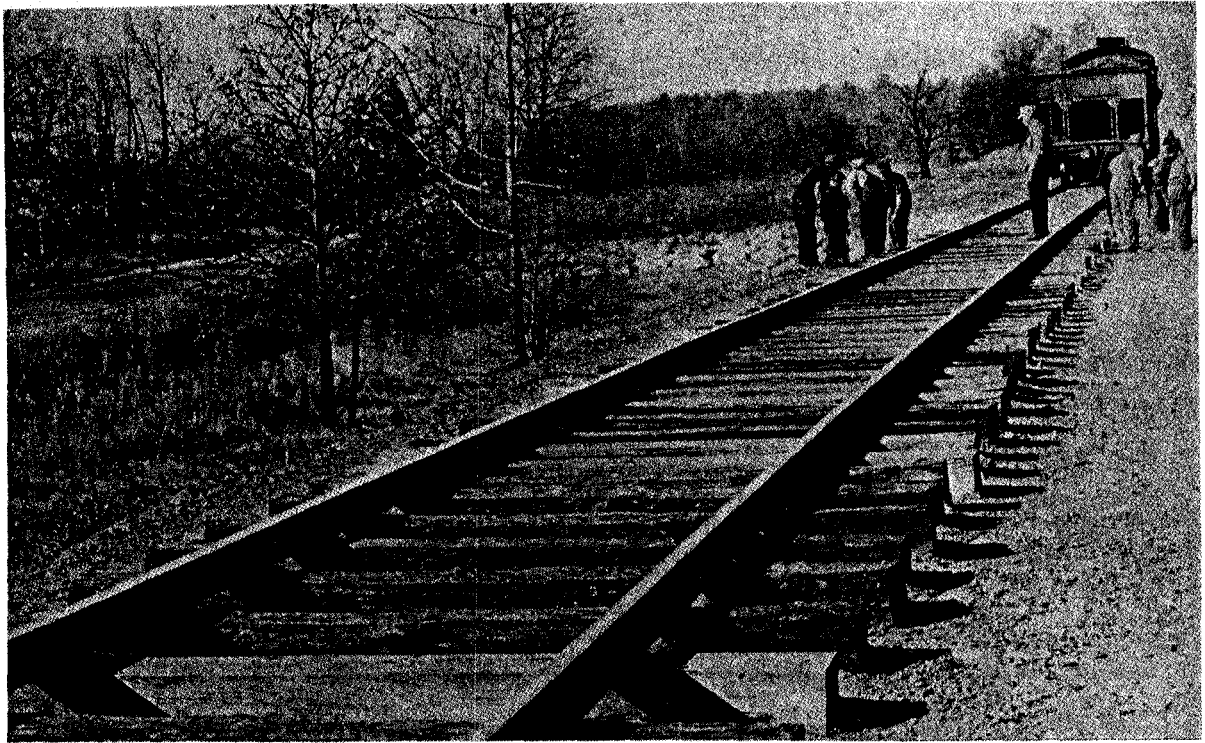


Figure 3-3. Track skeletonized to receive ballast.

way section. Clean or rake the berm. Surplus ballast left over from trimming should be disposed of in an appropriate area.

3-6.6. Cleanup. After the ballast is cleaned or renewed, remove all materials, tools, and equipment

used to perform the work; install and secure promptly all stock guards, crossing planks, and similar facilities adjacent to or forming part of the track; and dispose of all rubbish and waste remaining from the operation. Do not litter the right-of-way.

Section 3. TIES

3-7. General.

Nearly all railroad trackage on military installations has been constructed on wood ties. The use of wood ties for most such trackage will be continued, but there are circumstances where the use of concrete ties may be warranted. Trackage constructed on concrete ties in recent years by several commercial railroads has indicated that some of the potential advantages of concrete over wood ties include longer in-use life, greater strength, and better ability to hold rails permanently in line and to gage.

3-8. Wood Ties.

The service life of wood ties depends on the kind of wood, the method of treatment, the mechanical protection afforded, the severity of use, and climatic conditions. The use of untreated wood ties can no longer be justified. Only treated wood ties are to be

purchased or used. Design and specification of ties used in maintenance and repairs must conform to AREA Standards and/or Federal Specifications and should match the ties in existing adjoining work (see Appendix G).

3-8.1. Preservative Treatment. Pressure treatment with creosote has proved to be the most effective and practical preventive of decay (rot) and insects. Damage to wood fibers during spiking is less in treated than in untreated ties. Water repellance is better in treated than in untreated ties. Coal-tar creosote, solutions of wood-tar and coal-tar creosotes, and oil-borne solutions of pentachlorophenol are the most common preservatives used for wood ties. Pressure treatment is more effective than field treatment because preservatives applied under pressure penetrate the wood deeper and more uniformly than they do when applied in the field under no pressure. Consequently, field treatment is relied on only to

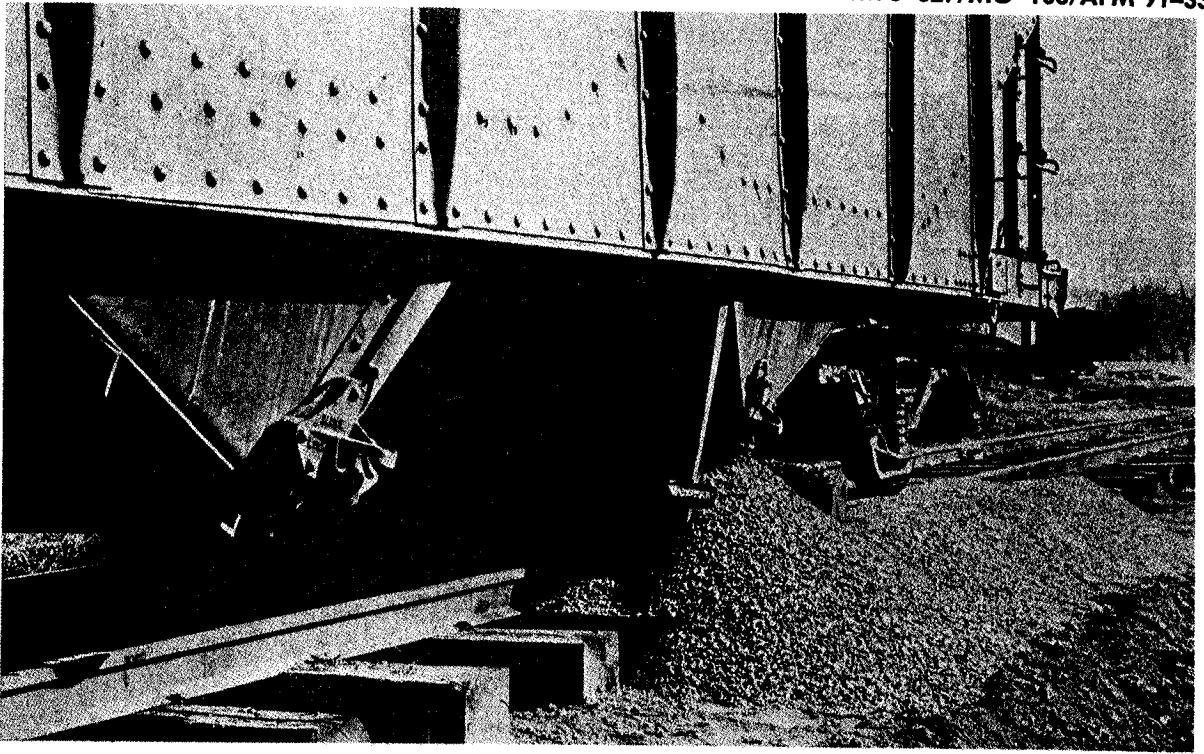


Figure 3-4. Distributing ballast from hopper car.

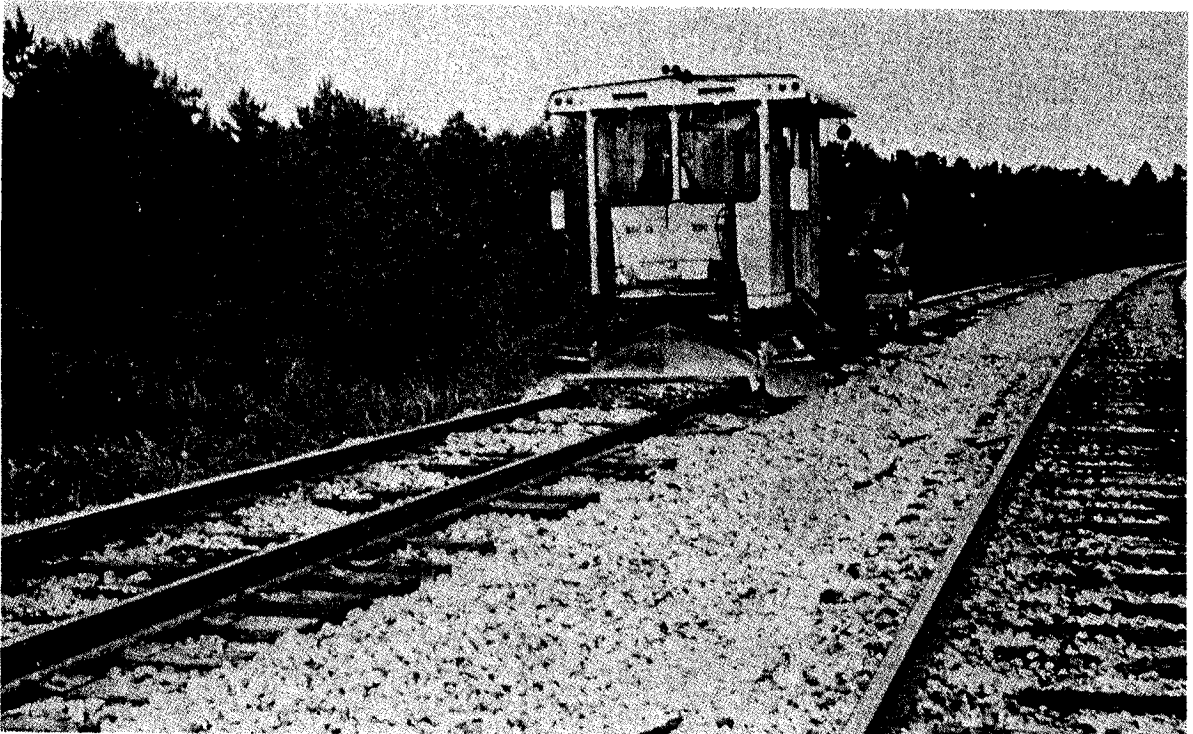


Figure 3-5. Ballast plow.



Figure 3-6. Hand-placing ballast after mechanical distribution.

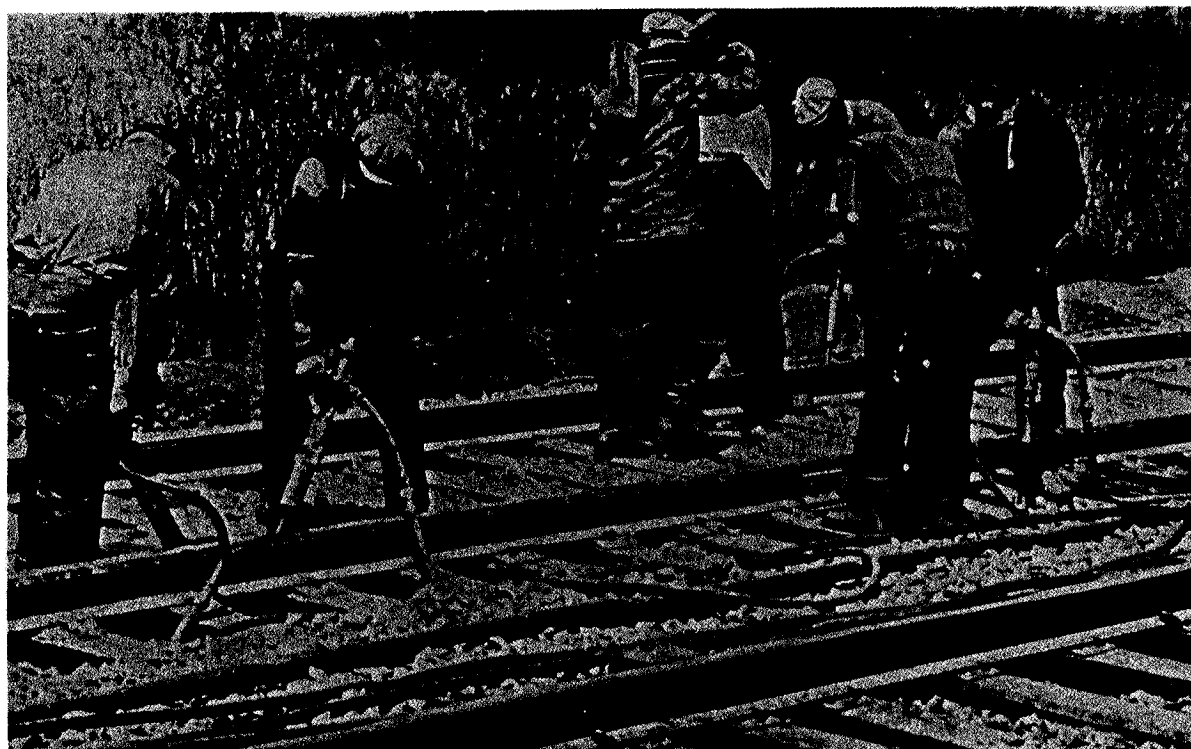


Figure 3-7. Manually tamping ballast with compressed air tools.

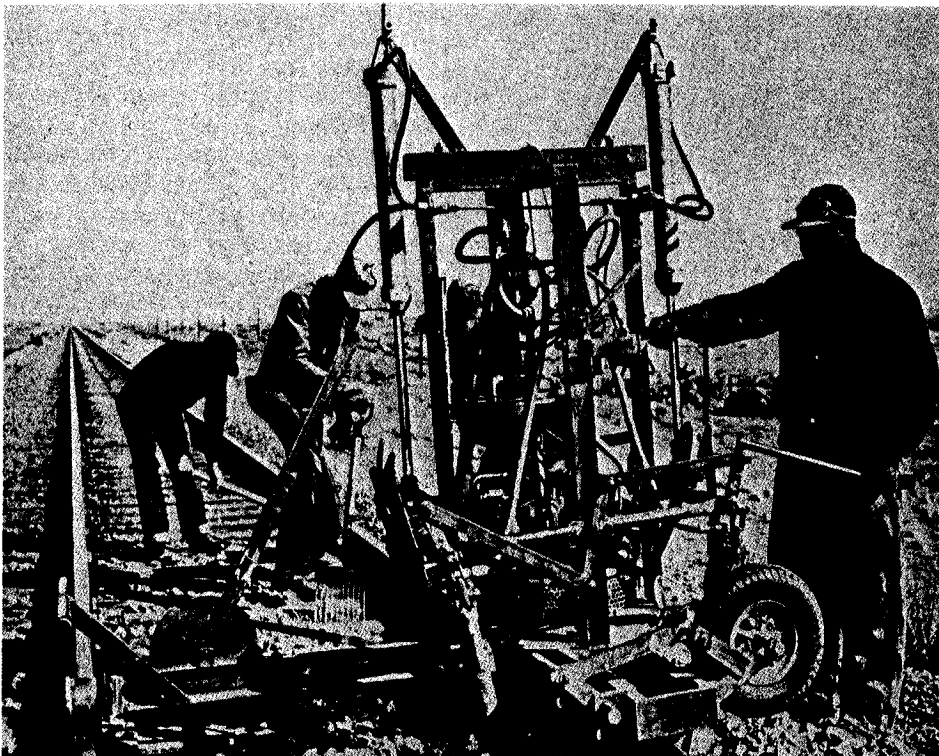


Figure 3-8. Machine tamping ballast.

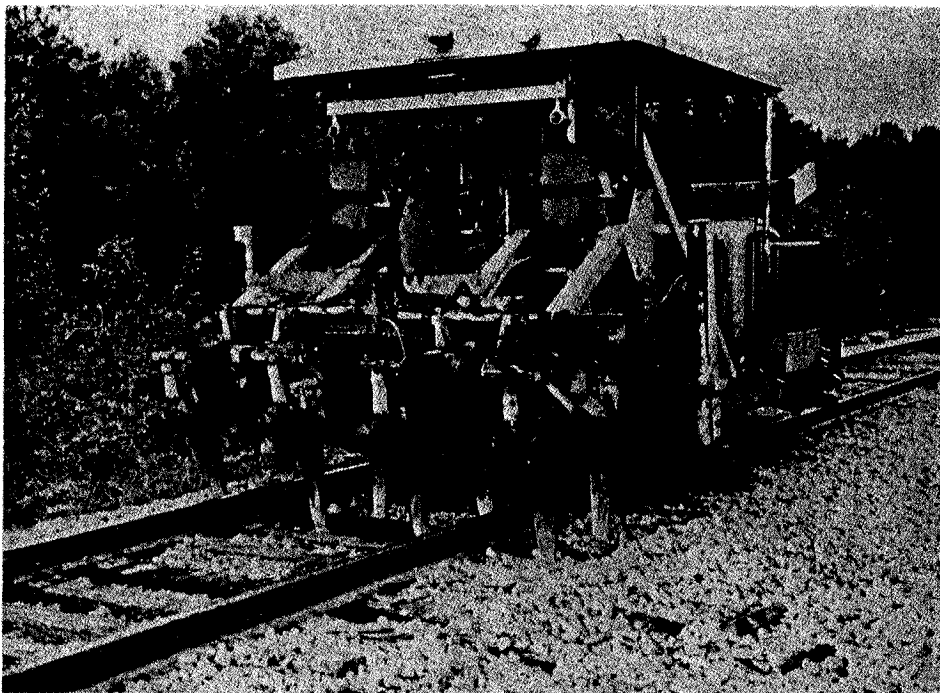


Figure 3-9. Large ballast tamping machine.

supplement pressure treatment; i.e., where it becomes necessary to penetrate the treated "shells" of pressure-treated ties by cutting, adzing or boring, etc.), the resultant exposed untreated wood is to be treated with field-applied creosote. Treating shall conform to the standards of the American Wood Preservers Bureau.

3-8.1.1. Any fabricating such as end trimming and, if required, adzing and boring or application of antisplitting devices (irons) (Figures 3-10 and 3-11 or dowels (Figure 3-12) should be performed before the ties are pressure treated. Seldom are the treated shells of such ties damaged while being properly handled and placed. Where the pressure-treated shells are unavoidably damaged, field-applied preservative is to be provided.

3-8.1.2. Because switch ties are not of uniform length (Figure 2-13) and because the locations of switch components cannot be predicted, switch ties are not adzed or bored before pressure treatment. The prefabrication of switch ties should consist of cutting and installation of antisplitting devices only. The field adzing and boring of switch ties is to be followed by carefully applied field preservative treatment.

3-8.1.3. The field treatment is to consist of two applications of hot creosote. On flat untreated surfaces (where ties have been adzed or cut), the material shall be brush applied. Unused bored holes or spike holes are to be filled with tight-fitting, soft wood, treated plugs firmly driven into the holes.

3-8.2. Handling Wood Ties. Broken, bruised, gouged, and otherwise damaged ties are the result of careless handling. Ties are not to be unloaded by dropping or throwing them onto rails, rocks, or hard or paved surfaces. Ties handled with tongs suffer less damage than ties handled with bars or sharp tools. Figures 3-13 through 3-16 illustrate the proper method of handling wood ties. The proper manner in which wood ties are to be stacked when they are not to be used immediately is shown in Figure 2-15 (para 2-4). Stacks of ties in areas exposed to sparks or other fire hazards can be protected by covering the stacks with earth or sand.

3-8.3. Safety. Creosote is a skin irritant, and splinters are a constant hazard in the handling of ties. All personnel who handle ties must wear appropriate gloves (Figure 3-16). Other common hazards are the dropping of ties and other heavy objects and tripping over tools and supplies. All personnel exposed to these hazards will wear safety shoes.

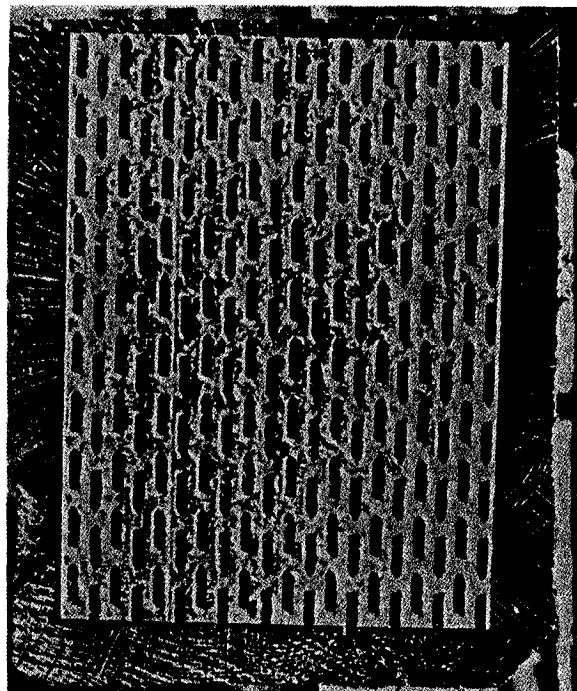
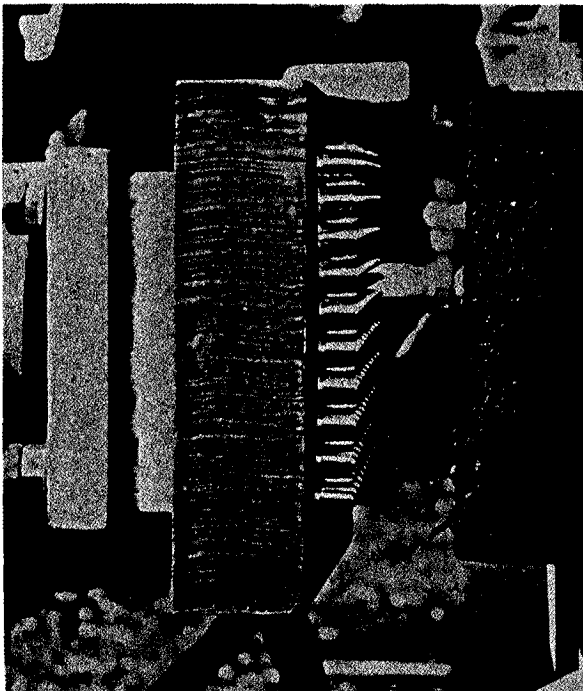


Figure 3-10. Antisplitting device.

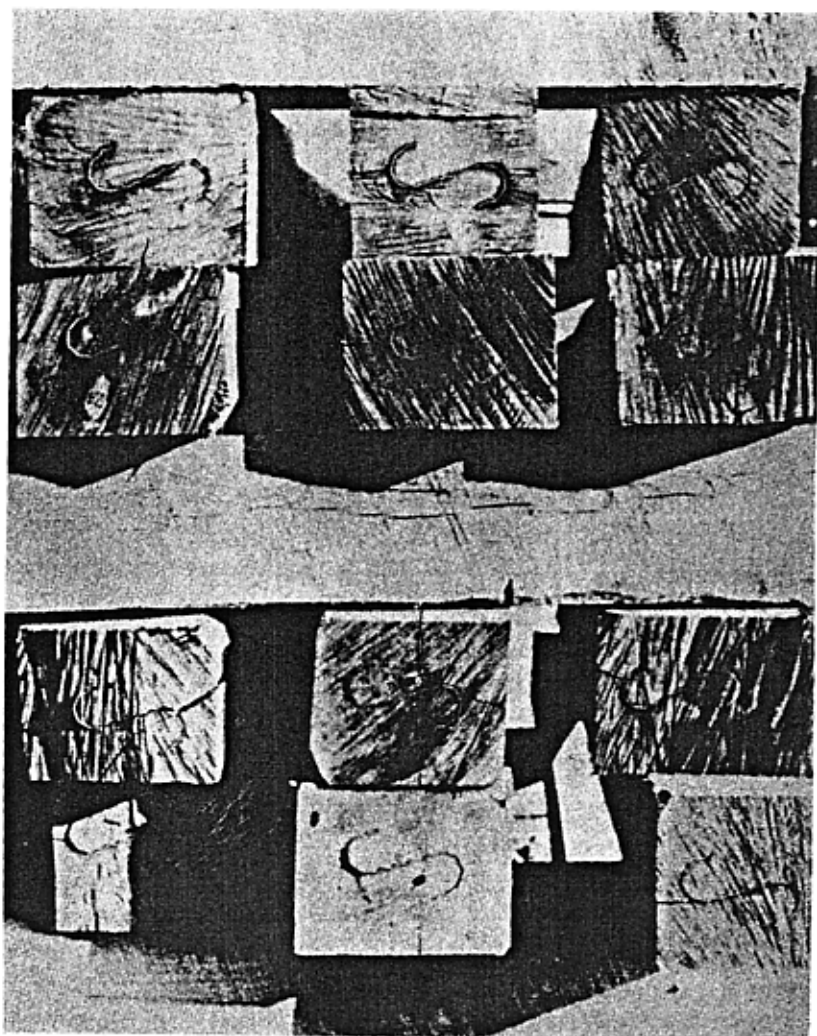


Figure 3-11. Antisplitting irons installed in ties.

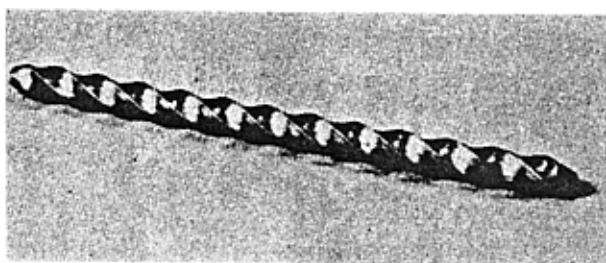


Figure 3-12. Tie dowel.

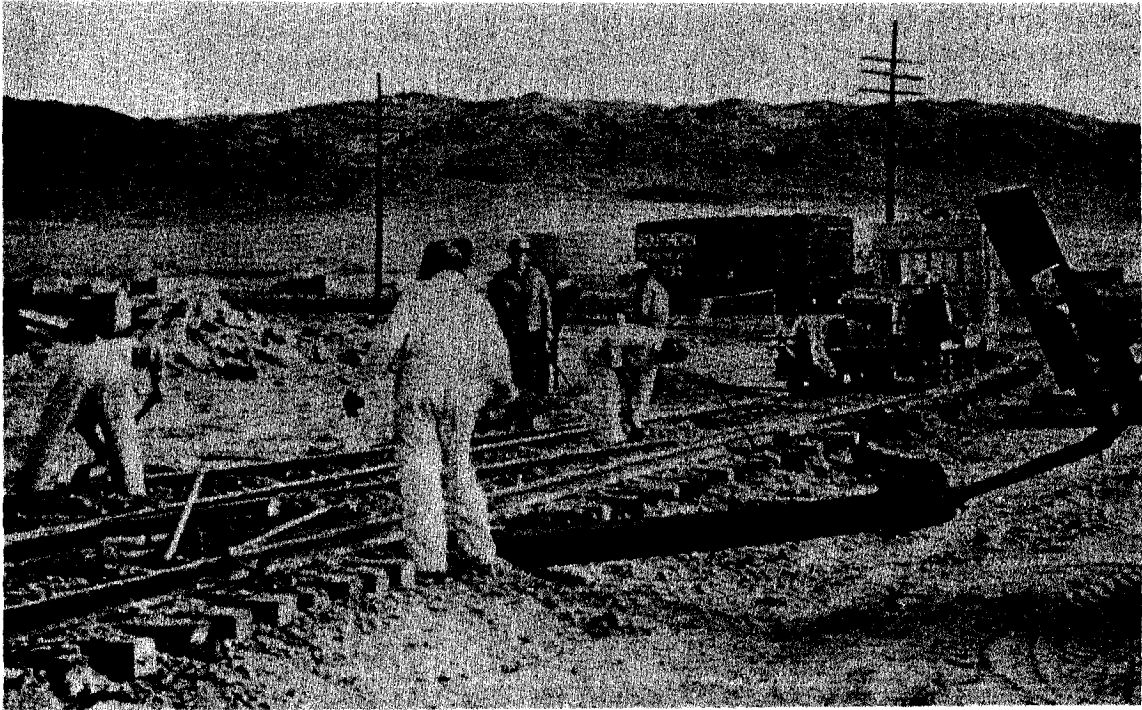


Figure 3-13. Typical switch tie installation.



Figure 3-14. Installing ties with hand tools



Figure 3-15. Installing ties with a tie crane.



Figure 3-16. Handling treated wood ties.

3-9. Ties Other Than Wood.

Decisions on the use of ties other than wood are to be made by a qualified authority and shall be based on comparative cost estimates reflecting all factors. The longer in-use life of concrete ties may justify their use in areas where tie inspection and maintenance work entail pavement removal, or at critical locations where track maintenance work results in serious operational problems (i.e., crossings, paved streets, paved industrial areas).

3-9.1. Concrete and Composite Tie Data. The Federal Specification covering concrete and composite ties has not been completed. Meanwhile, specifications for the ties will be developed for individual installations by those responsible for engineering at the military installations or at the offices of higher echelons of the engineering elements of the Departments of the Army, the Navy, and the Air Force.

3-9.2. Other Material. Ties made of composite materials and other state-of-the-art materials leading to tie substitutes may be used as available and proven in service.

3-9.3. Handling Concrete Ties. Workmen must wear appropriate safety shoes when handling ties. All ties shall be unloaded and loaded mechanically. Figure 3-17 illustrates the proper method for unloading concrete ties. Where ties must be stacked, they shall be stacked mechanically. No ties shall be loaded, unloaded, or stacked by hand. Because each concrete tie weighs nearly 500 pounds, all ties are to be moved from the unloading area or from stacks to the work sites by rail or truck. After the ties have been distributed and placed mechanically as close as possible to their final position, then and only then are they to be manhandled into position in the track work.

3-10. Tie Sizes.

Current tie inventories at some military installations include wood ties of nonstandard dimensions. Such ties are to be used generally on side tracks and spurs, not on running tracks. Future purchases are to include only standard sizes of ties.

3-10.1. Wood Crossties. Wood crosstie dimensions for military trackage should be selected based on the

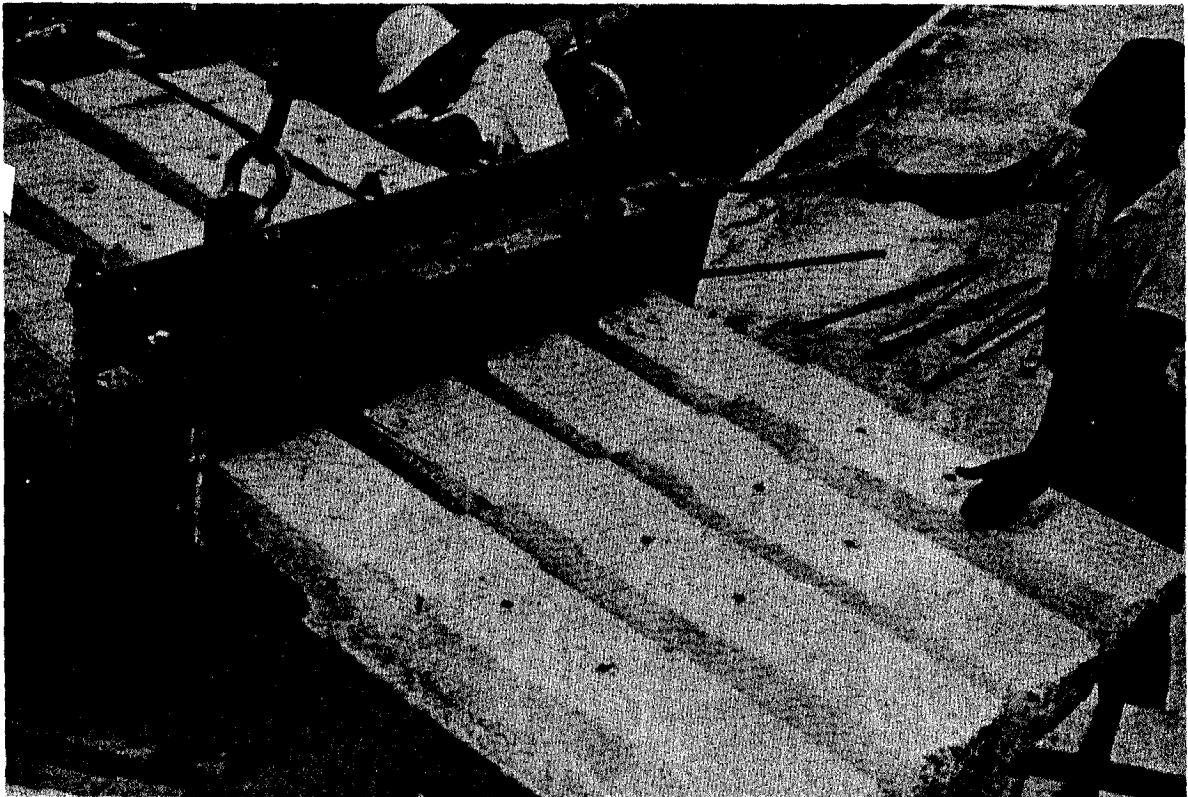


Figure 3-17. Handling concrete ties.

trackage category (para 1-10). Ties for running and access tracks should be at least 7 inches thick, 8 inches wide, and 8 feet 6 inches long. Ties 6 inches thick, 7 or 8 inches wide, and 8 feet long may be used for low-use trackage. In addition, ties 7 inches thick, 9 inches wide, and 9 feet long should be used where warranted, in accordance with AREA recommendations and this manual (para 4-11). Cross-sectional tie dimensions apply between 20 and 40 inches from the center of the tie.

3-10.2. Wood Switch Ties. Wood switch tie cross sections are 7 by 9 inches. The bill of materials in Figure 3-18 lists the lengths of 7- by 9-inch ties specified by AREA for No. 5 through No. 20 turnouts.

3-10.3. Wood Bridge Ties. The lengths of wood bridge ties are determined by the design of the bridge on which they are to be used. Normally, the minimum length is 10 feet, and the minimum cross section is 8 by 8 inches.

3-10.4. Concrete Crossties. The minimum length of concrete crossties is 8 feet 6 inches. Figure 3-19 shows a typical concrete tie. The dimensions of concrete ties may vary slightly between the products of different suppliers but will conform generally to the same configuration.

3-10.5. Concrete Switch Ties. Concrete switch ties are not currently available.

3-10.6. Concrete Bridge Ties. Standard concrete crossties may be used as bridge ties, *when approved by qualified engineering authority.*

3-11. Tie Replacement and Reuse.

In general, ties should not be replaced until decayed or mechanically worn beyond serviceability for the purpose intended. However, where general track reconditioning (ballast and rail removal) is under way, consideration should be given to replacing ties that are near the end of their serviceability so that the track need not be disturbed again in the near future. Installation of used ties is normally confined to light-traffic or temporary lines, sidings, and dead-storage tracks. Replacement usually is considered in the following order of priority: (1) running or access tracks, (2) classification yard, and (3) siding and storage tracks.

3-11.1. Spot Replacement. Spot replacement is the replacement of an occasional defective tie or a small group of ties (no more than 10 or 10 percent of the ties) from a length of track in which all the other ties are in satisfactory condition.

3-11.2. General Replacement. General replacement involves a larger number of ties (over 10 percent) from a length of track in which only occasional ties or small groups of ties are in satisfactory condition.

3-11.3. Identifying Defective Ties. Tie replacement will be made only after tie inspections have been completed and defective ties marked (Figure 3-20 and 3-21) for removal. Chapter 7 of this manual and the FRA Track Safety Standards (Appendix B) describe defective ties. Due to the movable parts at switches, the switch ties must be maintained in better condition than the crossties. Ties under the



Figure 3-19. Typical concrete tie.



Figure 3-20. Spot marking ties for removal.

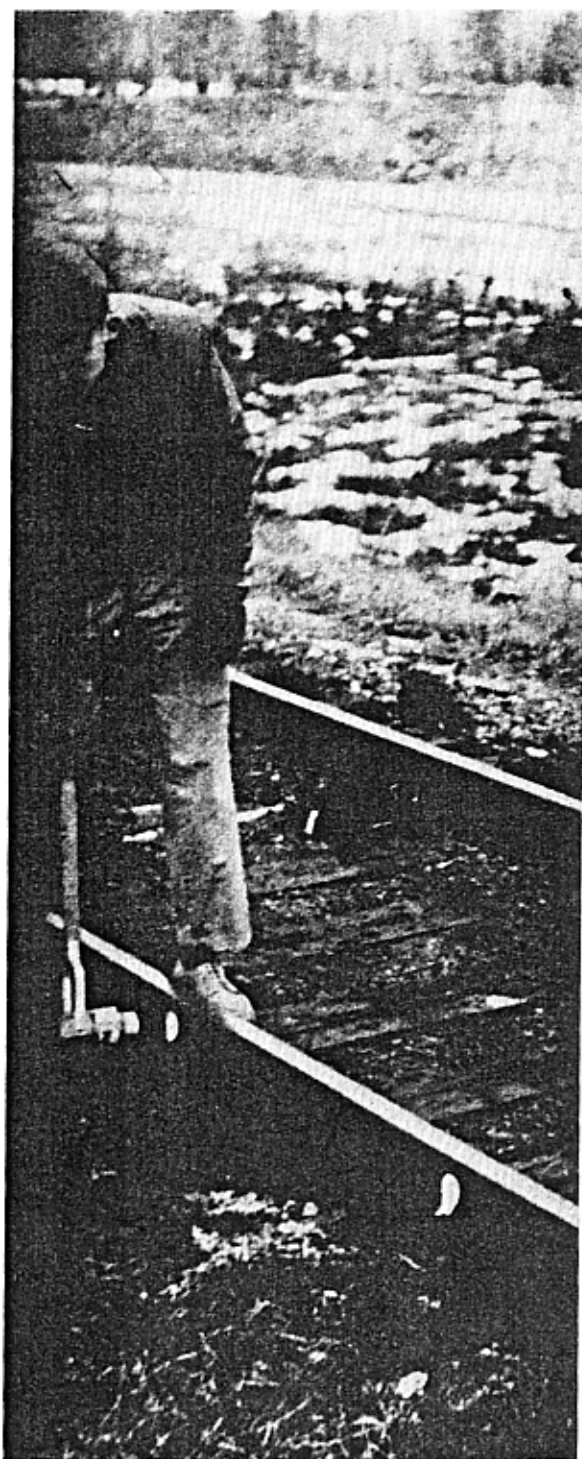


Figure 3-21. Spot marking rail with paint.

switch points and at the frog should never be allowed to reach the condition of crossties for Class 2 track. Only ties marked for removal will be replaced. Replacement ties shall be inspected prior to installation for compliance with applicable AREA Standards and/or Federal Specifications and for damage or deterioration while in storage or while being handled.

3-11.4. Tie Spacing. Tie quantity and spacing is based on roadbed conditions, trackage category, rail size, anticipated load, and experience or engineering judgement. Installation criteria for new construction and rework trackage should be specified for each section of trackage based on current instructions, design standards, need, and economics.

3-11.5. Spacing for Spot Replacement. For spot replacement of wood with wood ties, spacings will not be changed. However, the face-to-face separation between ties shall be at least 10 inches, but less than 16 inches. Skewed ties shall be straightened.

3-11.6. Spacings for General Replacement. When replacing wood with wood ties, standard spacings should be as designed: 22 to 24 ties per 39 feet of running track, and 20 to 22 ties per 39 feet for low-use trackage. In no case shall less than 18 ties per 39 feet be present in any section of trackage. Tie-spacing gages will be used except where variations in wood

tie cross sections and placement make its use impractical. Figure 3-22 illustrates such a gage welded to a shovel. Proper spacings for concrete ties are to be determined by a qualified engineer.

3-11.7. Skewed Ties. A skewed tie is one having an axis other than perpendicular to the rails (except turn out rails). Skew distance, as shown in Figure 3-23, is measured along the base of a rail on the gage side. Measurements of skew distance may be made while checking gage; however, a visual check at any track-age system is adequate. Spotting ties that are over half the width of a tie out-of-line can be easily done while walking or riding over the trackage system. Single skewed ties are not serious. Sections of track-age with skewed ties indicate a problem area that should be investigated.

3-11.8. Alignment of Ties. When placing standard length wood ties in double tracks, align the outside ends of ties. For three or more tracks, align the outside ends of ties with the outer tracks; align the ties of inner tracks the same as for single track. For single track, align the east ends of ties of north-south tracks, and the north ends of east-west tracks. Under-length wood ties shall be centered under the track.

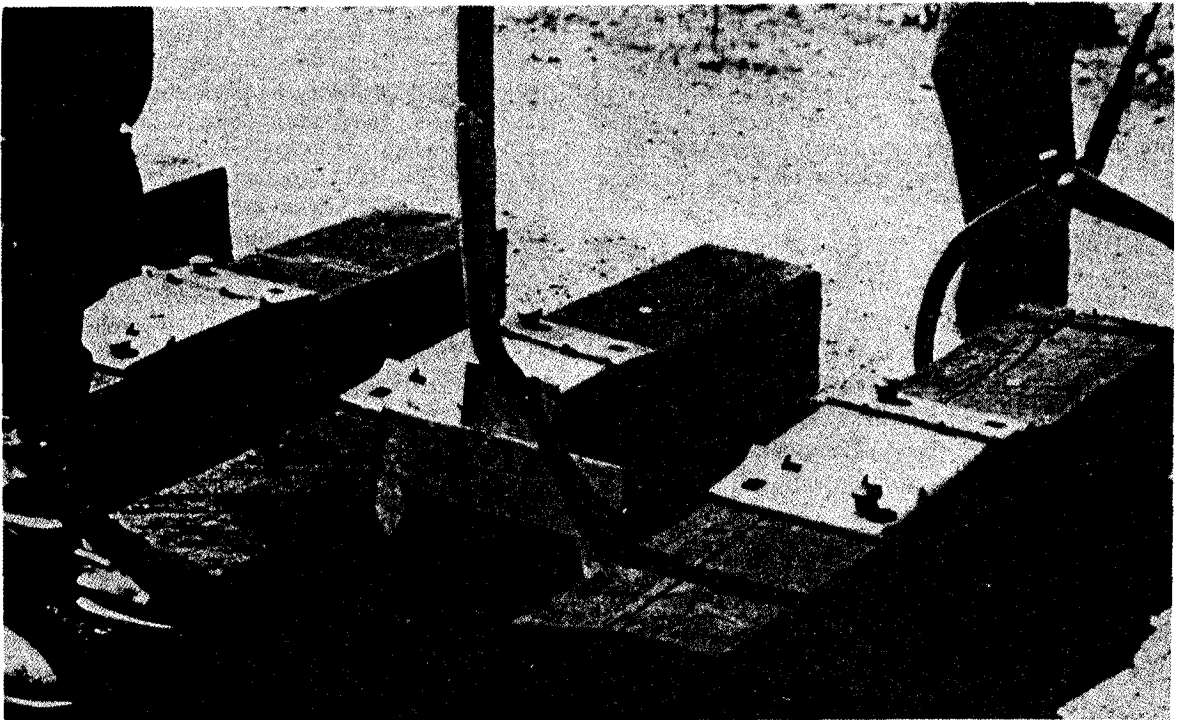


Figure 3-22. Tie spacing gage welded to shovel.

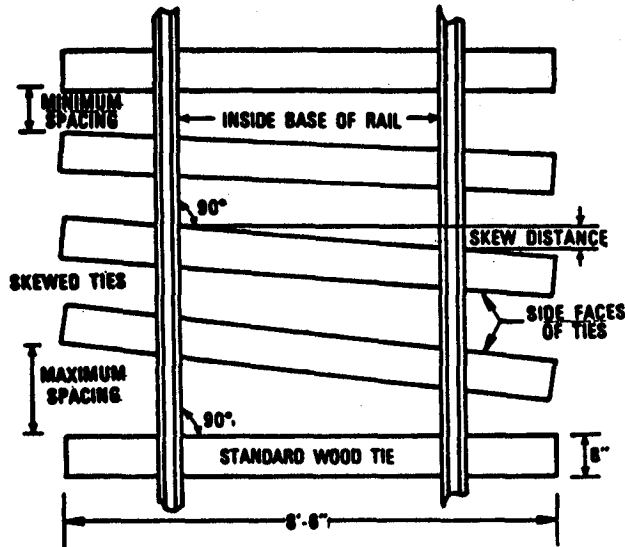


Figure 3-23. Railroad tie terminology and identification.

3-11.9. Procedures for General Tie Replacement. Traffic volume and the availability of alternate trackage may dictate replacement procedures. When a track can be removed from service without interrupting functions, a complete removal and replacement program is recommended. Verify and reference line and grade of existing trackage and remove the rail and ties. As in new construction, grade the ballast; salvage excess ballast; set the replacement ties and rail; and bring the track to proper alignment, grade, and surface. If the track cannot be removed from service, replace as many ties at one time as traffic permits.

3-11.10. Procedures for Spot Replacement. The following guidelines are applicable to the usual spot replacement programs:

3-11.10.1. After removing spikes, remove sufficient ballast from the crib to permit easy removal of the tie, pull the tie, and dress the roadbed.

3-11.10.2. Insert the replacement tie, accurately spaced and at right angles to the rail.

3-11.10.3. When replacement ties are wood, use the largest and best ties at rail joints. The distance from rail joint to the face of either adjacent wood tie shall not be more than 12 inches. Intermediate ties shall be evenly spaced.

3-11.10.4. Wood ties shall be laid heart-side down.

3-11.10.5. Spike wood ties to the rails at proper gage. Bolt concrete ties to the rails after placing the bearing pads.

3-11.10.6. Tamp ballast under the ties.

3-11.10.7. Avoid raising the track because ballast may run under adjacent ties. Instead of raising track, remove a little more ballast from under the tie being removed to facilitate the placement of the new tie.

3-11.10.8. Tamp under adjacent ties where one tie shows evidence of being cut by the rail base. The adjacent ties will then carry more of the load.

3-11.10.9. Tie plates will be used on running or access and heavy-use classification yard trackage. Tie plates are not required on temporary trackage except over bridges, trestles, or culverts and on curves sharper than 8 degrees (maximum radius 717 feet).

3-11.10.10. Avoid adzing ties. Adjust and tamp ballast to lower high ties. Where adzing is unavoidable, where different tie plates must be used, or where adzing is required to correct tie damage from a derailment, adze only the minimum depth. Then make a field application of preservative.

3-11.10.11. Fill unused spike holes with treated soft wood plugs, firmly driven into the holes.

3-11.10.12. Salvage all sound ties, spikes, and tie plates for appropriate reuse. Dispose of unsound ties and unusable materials.

Section 4. RAILS AND ACCESSORIES

3-12. General.

Design and specifications for rails and accessories should be in accordance with AREA Standards (Chapter 2, Section I). In repair and maintenance work it is important to match existing design of materials and construction wherever it is economically justifiable. In cases of individual rail replacement, where the existing rail does not meet the standard criteria listed herein and where the remaining track is performing satisfactorily, the same size rail should be installed. Rails must be connected at the joints so that the rails will act as a continuous girder with uniform surface and alignment. Rails and accessories obtained from suppliers or storage should be inspected before they are placed in track.

3-13. Rail Sections.

3-13.1. Standard Railroad Rail. Most of the existing substandard trackage at military installations consists of the 30- or 33-foot rails (Figure 2-1, para 2-3.1.). Rails required for replacement of worn or substandard trackage should normally be 39 feet long unless there is sufficient justification for using the shorter rail. The 90-lb/yd RA-A section, in 39-foot lengths, is satisfactory for most military installations except when wheel loading or spacing of supports require heavier rail. Heavier rail sections will be routinely used only to meet minimum requirements of the serving railroad when their locomotives are used on the installation. When it becomes necessary to

relay the existing 90-pound or lighter rails on running or access tracks and it is desired to use 115-pound rail, approval must be secured from the appropriate military service headquarters.

3-13.2. Ground-Level Crane Rail. Ground-level crane rail should be at least 135-pound CR for major replacement or new installations.

3-13.3. Elevated Crane. The rail section to be used shall be that which has been recommended by the crane manufacturer or equivalent to the existing rail. Rail sections shall accommodate all crane wheels.

3-13.4. Girder Rail. Rails of the street-railroad type, with deep webs, heads, and flangeways, are often used for trackage in pavement (Figure 3-24). (Figure 4-23 in Chapter 4 shows an installation of girder rail in a paved area.) Flangeways 2-1/2 inches wide shall be provided on tangent track and on curves of 8 degrees and under, and flangeways 2-3/4 inches wide on curves in excess of 8 degrees.

3-14. Rail Inspection.

All rails should be periodically checked. Some types of defects may be detected visually, and some by hitting the top of the rail with a hammer. Internal defects require the use of some type of electronic device to determine the type of defect. Figure 3-25 shows a sonic detector that can be used to detect defects within the joint bar area. A small ultrasonic tester is shown in Figure 3-26. Fissures are detected by a magnetic induction process.

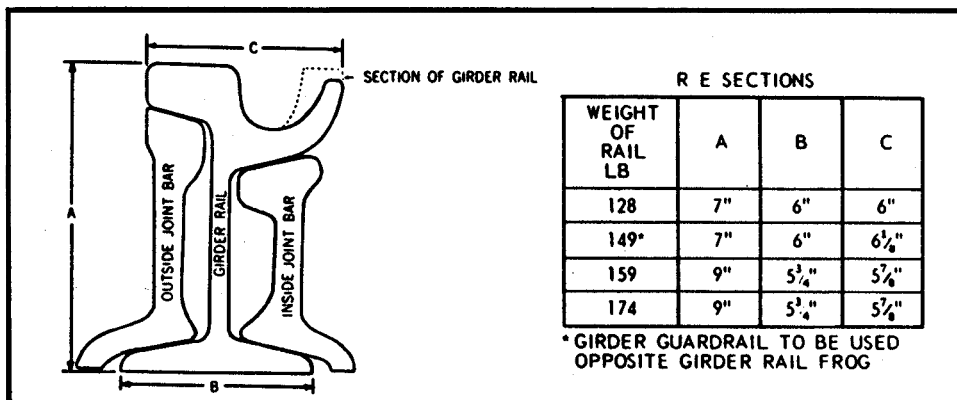


Figure 3-24. Details of girder rail.



Figure 3-25. Inspecting rail for flaws with a sonic detector.

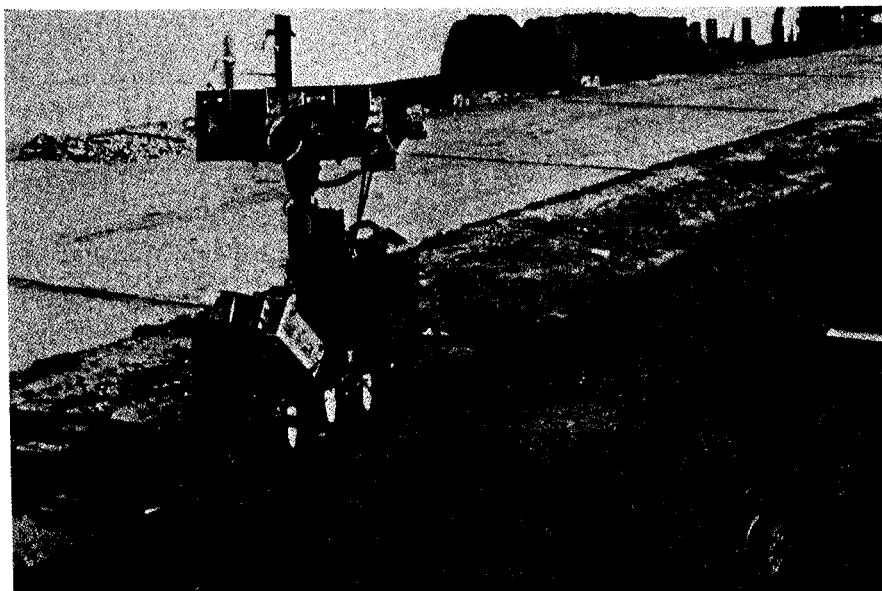


Figure 3-26. Ultrasonic rail detector.

3-15. Rail Failures.

Rails that are damaged to the extent of being hazardous to traffic should be replaced promptly. This applies particularly to locations such as switches, trestles, and the like where derailment might occur. Broken rails must be replaced immediately in any part of a track. Common causes of damage to rails are derailments, sliding wheels locked during braking, broken, flat, or unbalanced wheels, and stiff or unmoving trucks. Internal fissures can be detected only through the use of an ultrasonic testing device or some other type of rail flaw detector.

3-16. Common Rail Defects.

Figure 3-27 shows graphic examples of the following defects. Appendix B and Chapter 7 give additional descriptions, acceptable limits, and remedial actions to be taken.

3-16.1. Transverse Fissure. A transverse fissure is a crosswise break in the railhead, starting from a center or nucleus inside the head and spreading outward. The broken rail shows a smooth area around the nucleus, which may be either bright or dark, round or oval (Figure 3-27a).

3-16.2. Compound Fissure. A compound fissure is a horizontal split in the railhead that in spreading turns either up or down in the head (Figure 3-27b).

3-16.3. Horizontal Split Head. A horizontal split head is a horizontal break beginning inside the head of the rail and spreading outward; it is usually indicated on the side of the head by a lengthwise seam or crack or by a flow of metal (Figure 3-27c).

3-16.4. Vertical Split Head. A vertical split head occurs through or near the middle of the head. A crack or rust streak may show under the head close to the web, or pieces may split off the side of the head (Figures 3-27d and 3-28).

3-16.5. Crushed Head. A crushed head is a flattening or crushing down of the head (Figure 3-27e).

3-16.6. Split Web. Split webs are lengthwise cracks extending into or through the web (Figure 3-27f and g).

3-16.7. Piped Rail. A piped rail is a rail split vertically, usually in the web (Figure 3-27h).

3-16.8. Broken Base. A broken base is illustrated in Figure 3-27i.

3-16.9. Square or Angular Break. Square or angular breaks are illustrated in Figures 3-27j and 3-29).

3-16.10. Broken Base and Web (Bolt Hole Break). A broken base and web is a break in the web extending to the base (Figure 3-30).

3-16.11. Other Defects. In addition to the defects listed above, flaking, slivers, flowing, engine burn, mill defect, bolt hole crack, and top and side wear of

the head are shown in Figure 3-27k-4. Most of these are considered minor.

3-17. Replacement of Rails.

Where rails are to be replaced or interchanged, the following rules apply:

3-17.1. Inspection. Before placing any rail in track, inspect it thoroughly for possible failures and defects.

3-17.2. Salvage. Do not place badly worn rails in running tracks; save them for use in storage tracks. Reject rail that cannot be straightened.

3-17.3. Curve-Worn Rails. Reset curve-worn rails with the worn side facing away from the gage side. On curves, use the worn rail as the low or inside rail. **CAUTION:** This type usage is not recommended as changes in stress can cause failure.

3-17.4. Weight and Section. Match weight, section, and amount of wear of adjacent rails as closely as practicable. Do not connect rails with full heads to rails with worn heads where the gage of track at the joints would be altered appreciably.

3-17.5. Compromise Joints. When, by necessity, rails of different weights or sections are connected, use compromise bars to match the weights and sections of the two rails (Figure 2-3). Compromise joints are either right-hand or left-hand. To determine which is needed, refer to Figure 3-31. If large rail is on your left, the joint is left-hand; if on your right, it is right-hand.

3-17.6. Length of Rail. Do not use rails less than 13 feet long in running or access tracks, in classification or receiving yards, or where there is considerable movement of cars. Reserve such rails for dead storage tracks or extreme ends of stub tracks.

3-17.7. Broken and Cracked Rails. Remove broken or cracked rails from track immediately. If it is not feasible to replace the broken rail at once, use a pair of fully bolted joint bars at the break as an emergency measure. Remove the broken or defective rail as soon as possible.

3-17.8. Drilling Bolt Holes. Drill or punch the full number and correct size of bolt holes to coincide with the holes in the joint bars used. Hold joint bars in place with rail or C-clamps while the bolt holes are drilled, to insure correct spacing (Figure 3-32).

3-17.9. Traffic Precautions. If a rail is broken or defective and safety at normal speeds is questionable, give "slow" orders (Figure 3-33) for that section of track and move trains under direction of a flagman. Never use these measures at hazardous locations; stop traffic until defective rails are replaced.

3-17.10. Cutting Rail. As soon as possible, remove rails that have been cut with an acetylene torch to make a temporary closure. Cut off at least 6 inches of the torch-cut end of the rail with a rail saw (Figure 3-34) or cutting tool before using the rail in track again.

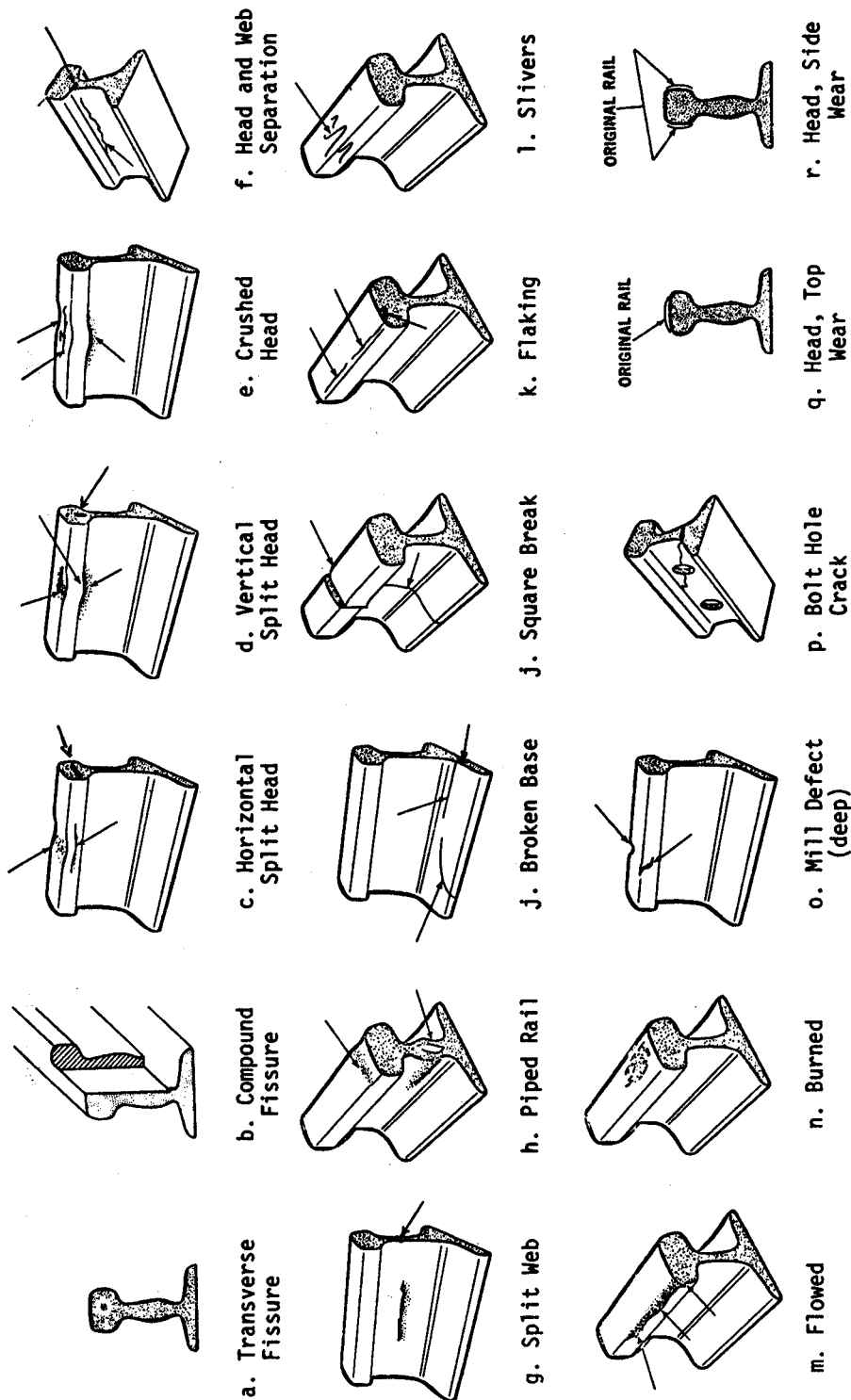


Figure 3-27. Types of rail failures.



Figure 3-28. Vertical split head.

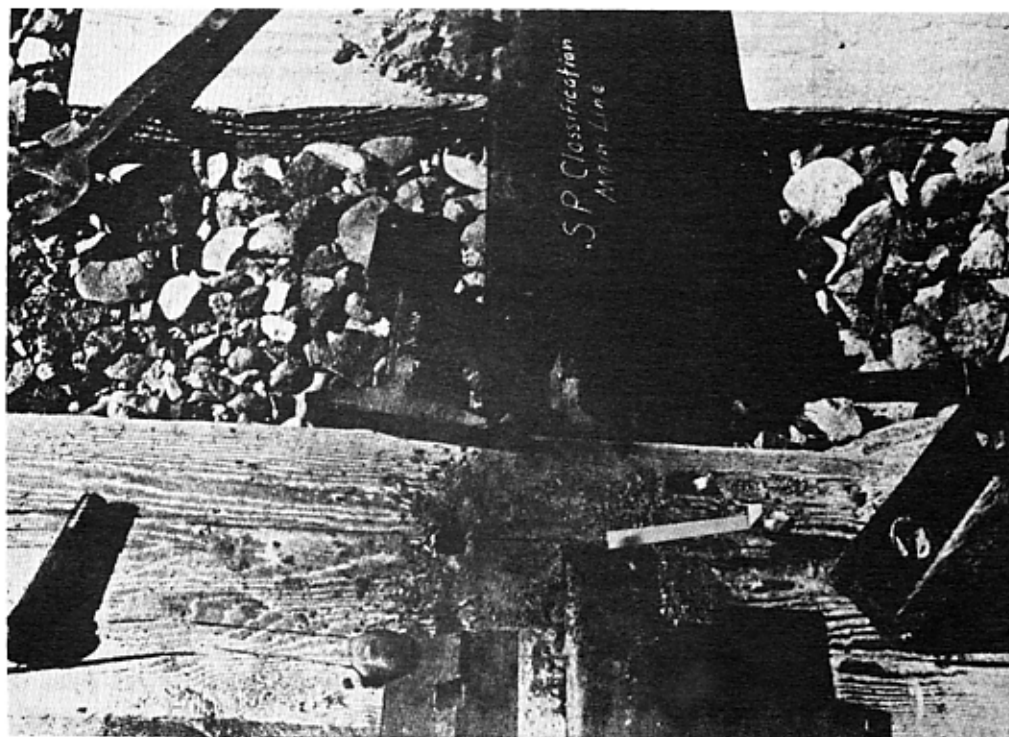


Figure 3-29. Square break in rail.

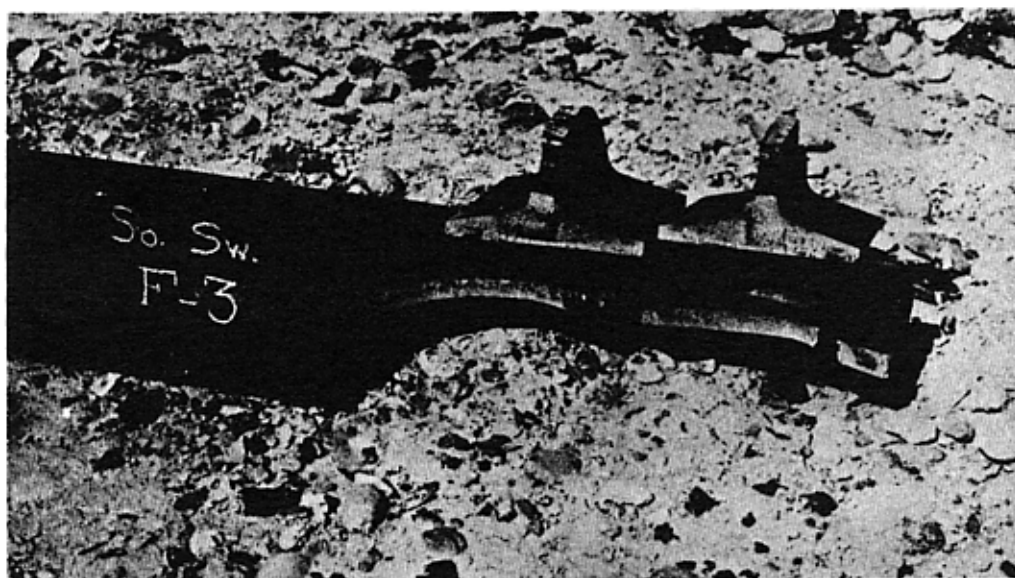


Figure 3-30. Broken base and web.

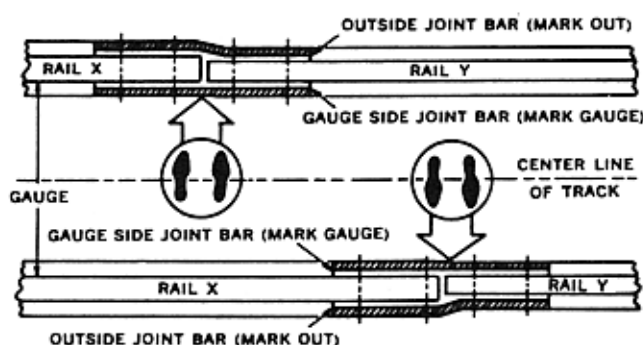


Figure 3-31. Compromise joint identification.

3-18. Welded Rail Replacement.

In continuous welded rail, a minimum of 13 feet shall be maintained between welds or joints. The method of welding shall be the preheated thermite process or another approved procedure. Joint bars are required

on welded rail when there are existing bolt holes in the rail. Joint bars are mandatory if there are bolt holes in either piece of rail being used in new or replacement work. Existing rail holes (not at the ends), such as bolt holes and old gage rod holes may be maintained as is, provided there are no other potentially serious defects in the immediate area.

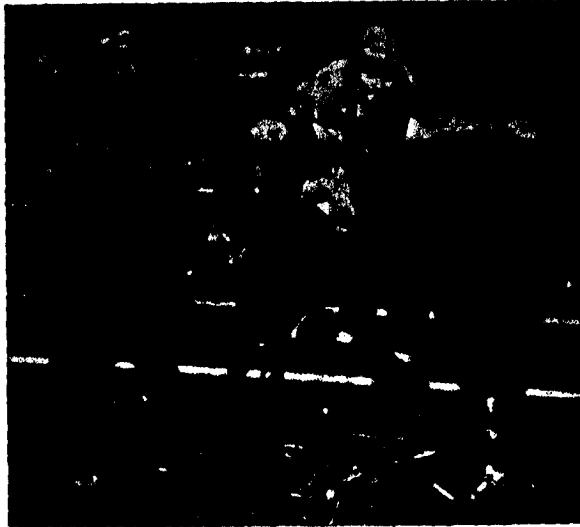


Figure 3-32. C-clamp.

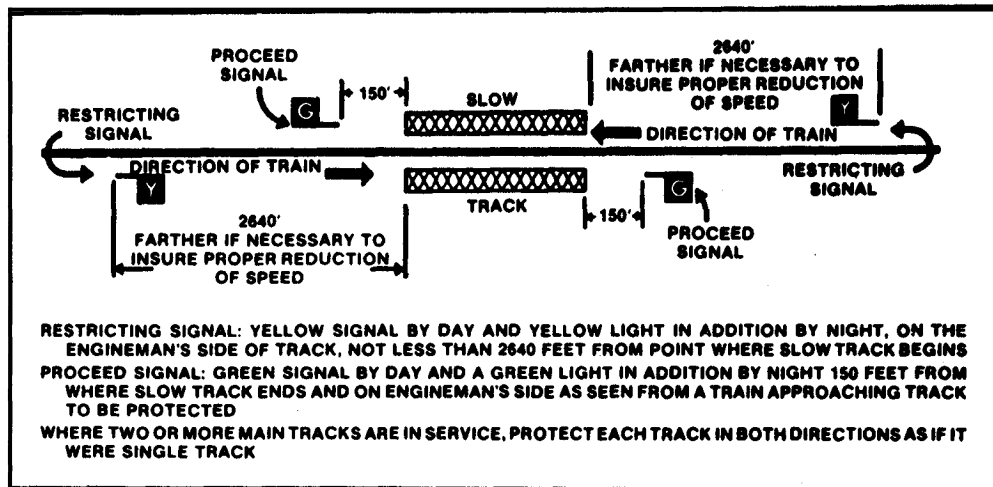


Figure 3-33. Details for establishing slow order.

3-19. Handling Rails.

Care must be taken in handling rails both in removing old rail for replacement and in delivering and placing new rail.

3-19.1. Precautions. Take care not to damage bolts, nuts, or rail anchors when removing rail from track. A crane should be used for loading rails when it is available. In most installation maintenance, it is necessary to load or carry rails by hand (Figure 3-35). Rail tongs must be used and the following precautions observed:

3-19.1.1. Divide the gang equally at ends of the rail. Utilize suitable lifting tools, distribute weight safely, do not overload crew (75 pounds per man is recommended maximum load), assure safe footing, and lift properly with back kept straight. Safety-toe shoes must be worn during such operations.

3-19.1.2. Designate one person to call directions.

3-19.1.3. Never attempt to throw rail.

3-19.1.4. Always load so that a person can jump clear if the rail should fall.

3-19.1.5. If there is a danger of operating personnel falling over rails distributed along the track,

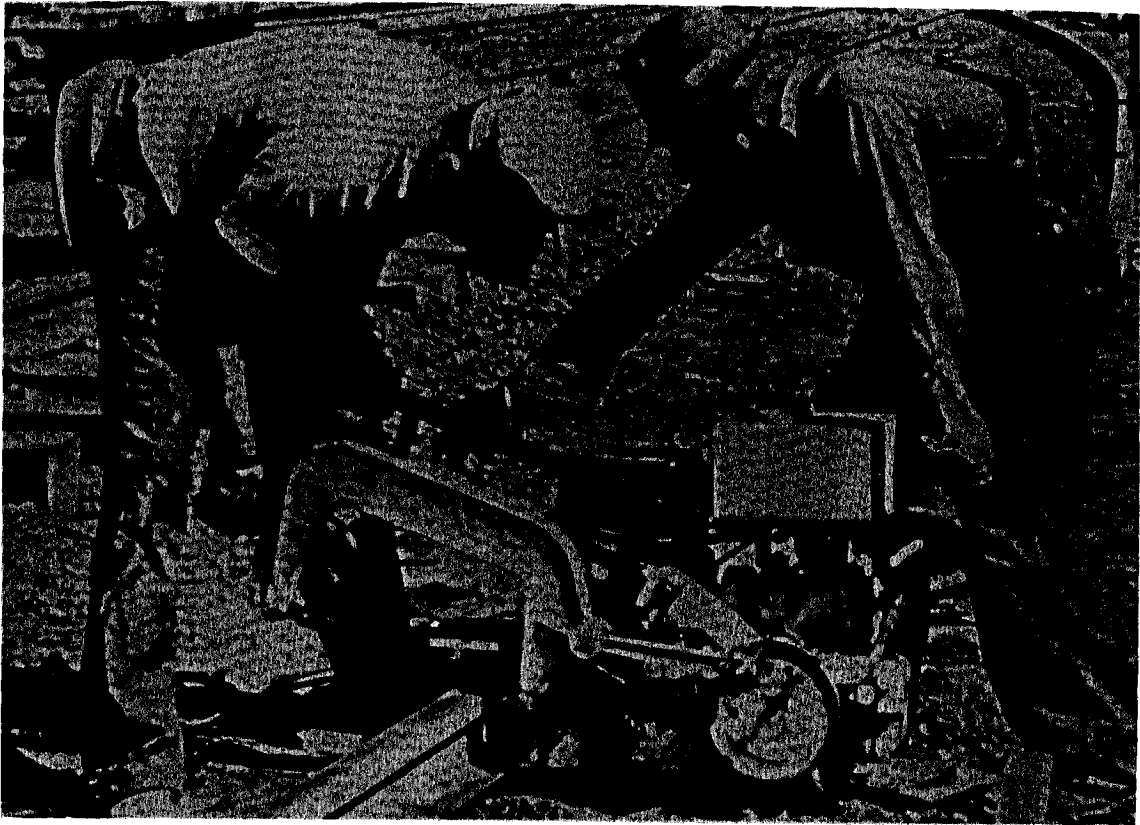


Figure 3-34. Cutting rail with a power saw.

report rail locations so they can be warned. Mark the obstructions with visible warning signs.

3-19.1.6. In yards and station grounds, stack rails well out of the way of operating personnel, and in a place convenient for distribution.

3-19.2. Distribution of Rails. Distribute rails so that they can be laid without unnecessary handling as follows:

3-19.2.1. Place rails base down (Figure 3-35), parallel with the track and with sufficient bearing to prevent bending or swinging, except where there is a hazard of movement due to vibration. Rail left between or adjacent to tracks must be left lying on side, unless on ground that is more than 1 foot below top of tie.

3-19.2.2. Rails should be unloaded opposite the locations in which they are to be placed in the track, allowing suitable gaps for short lengths.

3-19.2.3. Proper lengths of rail for road crossings, station platforms, bridges, and other special locations shall be unloaded in a safe and convenient location, where they will not constitute an obstruction.

3-19.2.4. To minimize the cutting of new full-length rails, shorter rails should be distributed in proper

places to provide for proper spacing at insulated joints and for connections to switches.

3-19.2.5. No rail less than one-half rail length shall be used in main tracks, except that shorter rails not less than 13 feet long may be used for temporary closures and for connections within turnouts.

3-19.2.6. Joints, turnouts, and fastenings should be unloaded and distributed concurrently with the rail, except that small material must be left in the containers until the time of laying the rail.

3-20. Preparation For Laying Rails.

Bring grade to true line and elevation before laying new rail, particularly on curves that are out of line. No part of the track structure in use shall be removed until the replacement rail is ready to be installed. Full flag protection or slow-order protection must be provided in cases where rail is being laid under traffic. See Figure 3-33 above for details of establishing slow orders.

3-20.1. Tie Plates and Bearings. Tie plates shall bear fully and uniformly on the ties, and the bearings on each tie shall be in the same place.

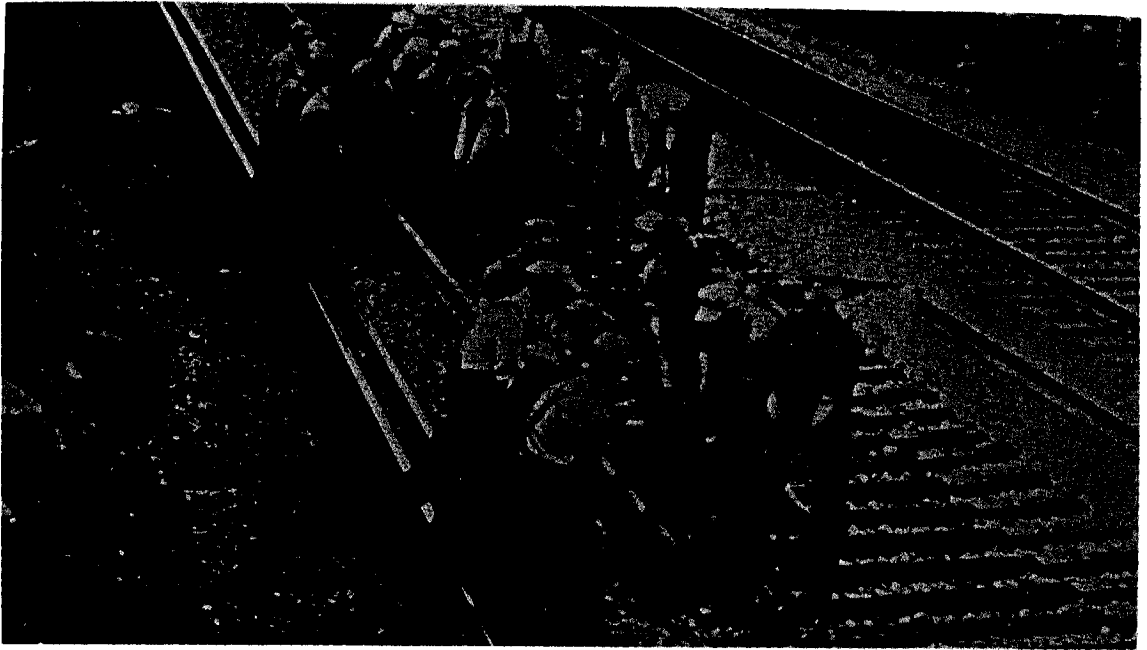


Figure 3-35. Handling rail manually.

3-20.2. Curved and Straightened Rails. When available, use a bender to precurve rails for sharp curves. Curvature must be uniform throughout the length of the rail. Straighten rails that have sharp crooks or bends (para 3-17.2).

3-20.3. Placement of Rail Accessories. Distribute bolts, spikes, tie plugs, tie plates, and rail anchors as close as possible to the site where they will be used, shortly before rail is laid. Do not put such articles on top of ties or in cribs when track is in use.

3-21. Steps In Laying Rails.

Never lay more rails than can be properly secured during the day in which they are laid to prevent damage to the rails or fastenings by normal traffic. Utilize mechanical devices to lay rails whenever possible. If this is not possible or practicable, extreme care must be exercised by personnel to preclude serious personal injury. Lifting and lowering of rails must be done with backs straight. A check list of the pertinent steps in rail laying follows:

3-21.1. Tamp loose ties to provide a good bearing under the new rail. Follow standards for spiking and bolting, and apply necessary rail anchors before permitting trains to pass over the rail.

3-21.2. See that insulating joints in the track circuit are spiked and supported as soon as possible, as insulating fibers are easily damaged.

3-21.3. Lay rails one at a time. To insure good adjustment, bring rail ends squarely together against suitable rail expansion gages, and bolt them before

spiking. Under special conditions, certain departures from this plan are permissible. In areas of heavy traffic, when trains cannot conveniently be diverted to other tracks, stretches of rail not over 1,000 feet long may be bolted together, and then lined into place. Proper allowance for expansion must be maintained (Table D-8, Appendix D); requisite rail expansion gages should remain in place until rails are set in final position. Figure 3-36 shows section of rail being lined off ties in preparation for relay.

3-21.4. Never use switch points to make temporary connections. This is a dangerous practice.

3-21.5. Provide holes for complete bolting of cut rails according to standard drilling practices and the following rules: (1) New holes must be drilled (Figure 3-37) or punched and not slotted, or burned with a torch. They shall not be drilled between existing holes (para 3-17.8). (2) The distance from the end of a rail to the center of the first bolt hole should be at least twice the diameter of the hole. (3) The distance between centers of any two holes of the same size should be at least four times the diameter of the hole; in the case of holes of different sizes, the distance should be at least 3-3/4 times the mean diameter of the two holes.

2-21.6. Paint the contact surfaces of all rail ends and angle bars with a lubricant equal to black lubricating oil just before laying the rails.

3-21.7. Install standard metal, fiber, or wood shims between the ends of adjacent rails to insure proper space allowance for expansion, as indicated in Table D-10.



Figure 3-36. Rail being lined out.

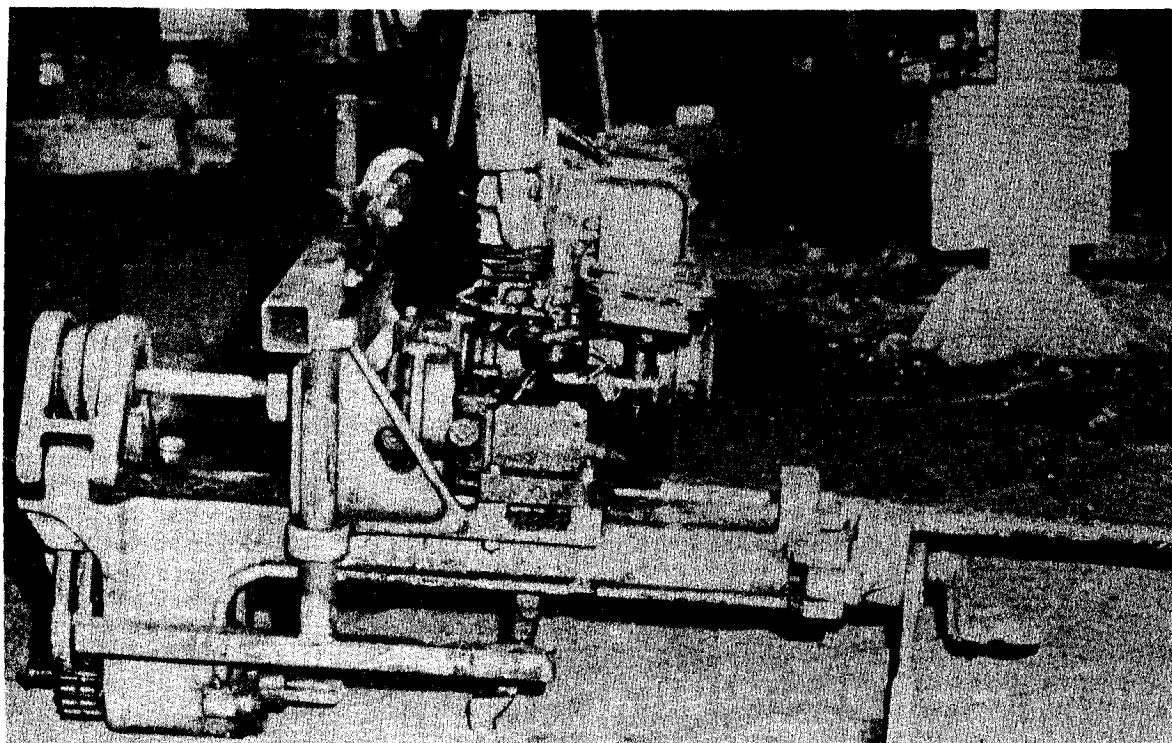


Figure 3-37. Rail drill.

3-21.8. Use a spike maul or a mechanical or pneumatic spike driver (Figures 3-38 through 3-40) to drive spikes. Spikes must be vertical and square

with the rail. Straightening spikes as they are driven decreases the holding power. Hold rail against gage when spiking.



Figure 3-38. Driving spikes with a spike maul.

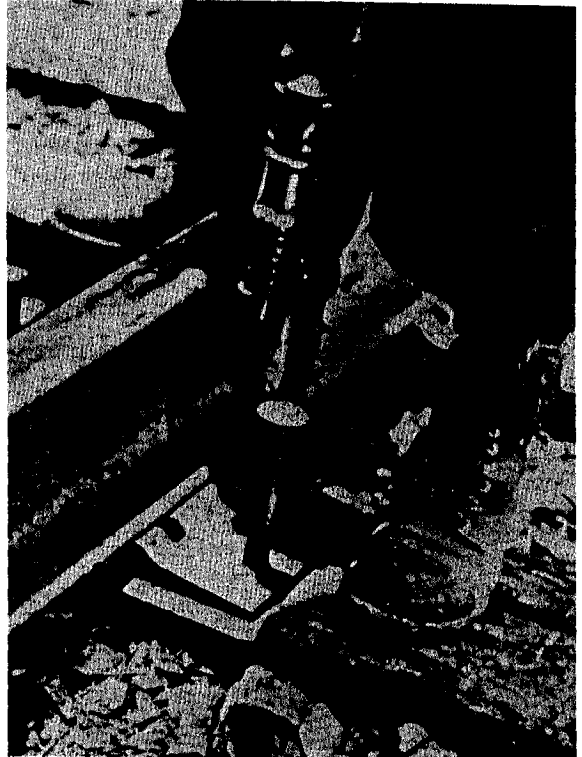


Figure 3-39. Driving spike through tie plate.

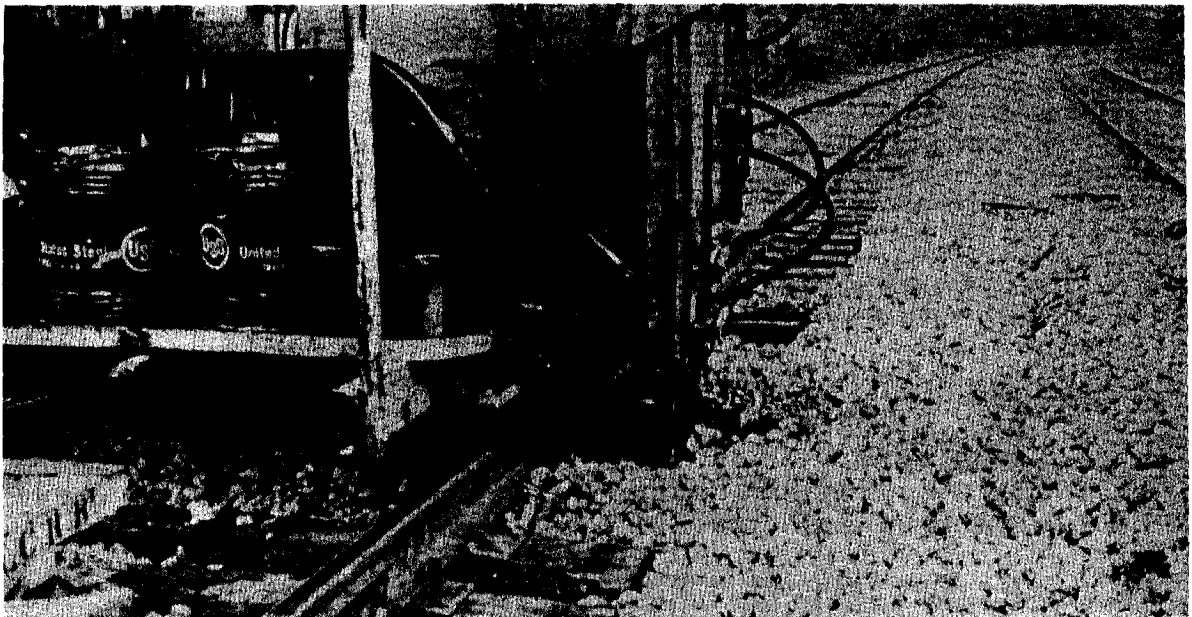


Figure 3-40. Power driven spike driver.

3-21.9. Use four spikes per tie on tangent trackage and on curves with less than 6 degrees of curvature (radius 955 feet or more). Spikes shall be staggered so that all the outside spikes and inside spikes on the opposite end of the tie are in relatively the same position in the tie, i.e., spikes should be in a "V" pattern with the "V" pointing in the direction of heaviest traffic. Spikes should be about 2 inches from the edge of the tie, except where tie plates are used, in which case they are driven through the spike holes (Figure 3-39).

3-21.10. On curves with more than 6 degrees of curvature (radius less than 955 feet) and at other critical points, use two spikes on the gage side of (inside) the rail and one on the field side (outside) (six spikes per tie), when using tie plates. If tie plates are not used, place one spike on the gage side and two spikes on the field side.

3-21.11. Drive spikes down snugly, but not tight against the rail. A space of approximately 1/8 inch should be left between the head of the spike and the base flange of the rail (Figure 3-41).

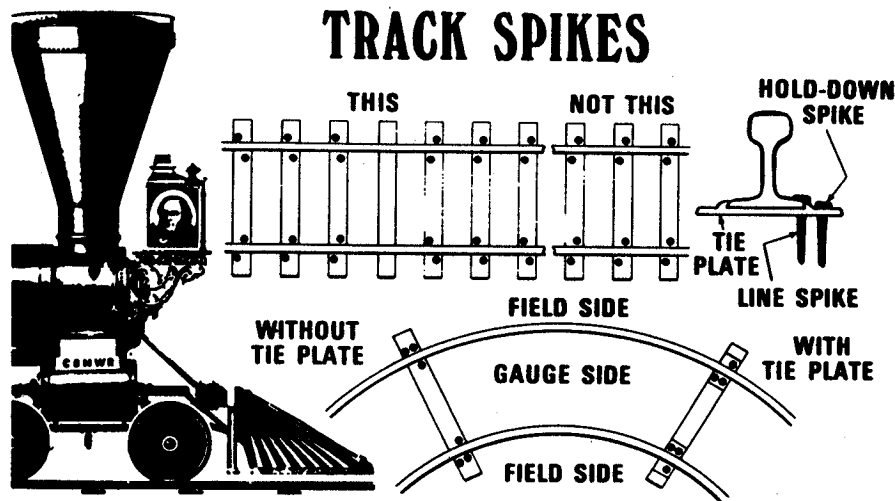


Figure 3-41. Proper spike placement.

3-21.12. Gaging shall be done at least at every third tie when laying the second line of rail.

3-21.13. Install rail anchors and gage rods, when required, before allowing traffic over new track.

3-21.14. When necessary to make a temporary connection for the passage of a train, the union shall be made with a rail of the section being renewed. The closure rail shall not be less than 13 feet long, and shall be connected to the new rail by a compromise joint if the rails are of different sections. The connecting rail shall have a full number of bolts and the required number of spikes.

3-22. Rail Joints.

3-22.1. General Requirements. Rail joints should fulfill the following requirements:

3-22.1.1. They should connect the rails so that they act as a continuous girder with uniform surface and alignment.

3-22.1.2. Their resistance to deflection should approach that of the rails to which they are applied.

3-22.1.3. Battered rail ends should be repaired by an approved method of welding and grinding.

3-22.2. Jointing. Lay rails so that the joints of one are opposite the middle of the other rail, with permissible variations as follows:

3-22.2.1. Except through turnouts and at paved road crossings, the staggering of joints should not vary more than 30 inches from the center of the opposite rail, preferably not more than 18 inches.

3-22.2.2. Do not locate joints within the limits of switch points, opposite guardrails, or within 6 feet of the ends of open-floor bridges or trestles.

3-23. Bonded Rails.

Where highway or train signals are actuated through the track circuit, or where petroleum fueling facilities or ammunition loading points require grounding of rails, rails must be constantly bonded by pin-connected (Figure 3-42) or welded bonds. The bonding may be applied to the outer side of the railhead, within the limits of the joint bars or outside of joint bars in the web of the rail.

3-23.1. Pin-Connected Bonds. For pin-connected bonding, the following steps are required:

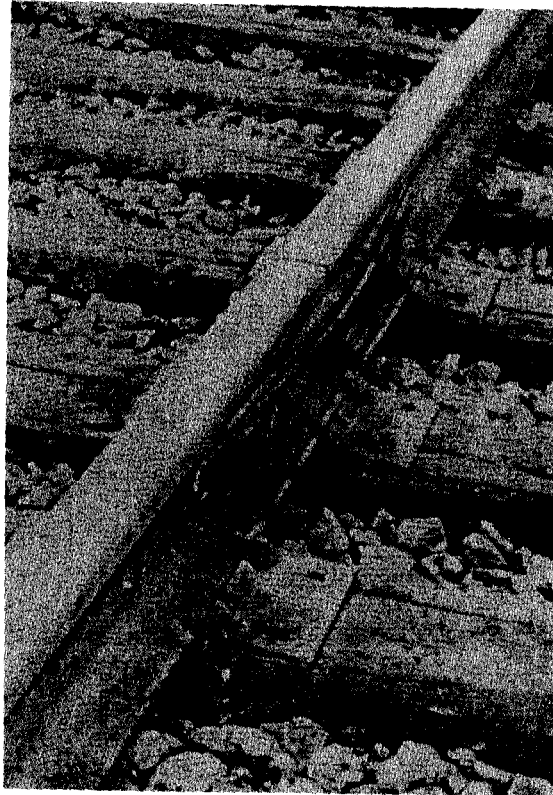


Figure 3-42. Properly pin-connected bonded rail.

3-23.1.1. Drill holes in head or web of rail the size of lugs on end of bond wires, and drive lugs into them to secure a firm fit.

3-23.1.2. Do not disconnect bonding wires or reverse bonded rails without an electrical maintenance crewman present. In emergencies when a broken rail, switch, or frog needs immediate repair, make as tight a connection as possible, but notify the electrical and communication maintenance officers at the first possible opportunity.

3.23.2. Welded Bonds. Use approved methods for welding bonds in lieu of pin-connected bonds where it is more practical.

3-24. Cutting Rails.

When available, use either a tooth or friction-type rail saw for cutting rails (Figure 3-34). When these automatic tools are not available, a rail chisel will suffice. In cases of extreme emergency, rails may be cut with gas cutting torches by qualified operators, but torch-cut rails should be replaced as soon as possible. When rails are cut with gas cutting torches, suitable face, eye, and other body protection must be afforded in the form of goggles, face shields, flame-proof gauntlet gloves, and other protective devices to prevent injury.

3.24.1. Rail Saw. Manufacturers' instructions should be followed in the operation and maintenance of mechanical saws. General rules that apply are: keep the machine clean, inspect at regular intervals, use proper adjustment, and see that the railroad maintenance crew takes care in handling and operation.

3-24.2. Rail Chisel. When using a rail chisel, the striker and the man holding the chisel must not face each other. Both must wear prescribed goggles. The chisel must be sharp and the head properly rounded. Use a sledge, not a spike maul. Place the rail on a block with the base of the rail up and the block a slight distance behind the cut. Do all cutting on the base and the web of the rail. Do not drop rails to expedite cutting; use the chisel until the cut is completed.

3-25. Joint Bars.

3-25.1. Installation. Joint bars are installed with the full number of bolts, nuts, and spring washers. Rails weighing over 75 lb/yd are bolted so that nuts alternate between the inside and outside of the track (Figure 3-43).

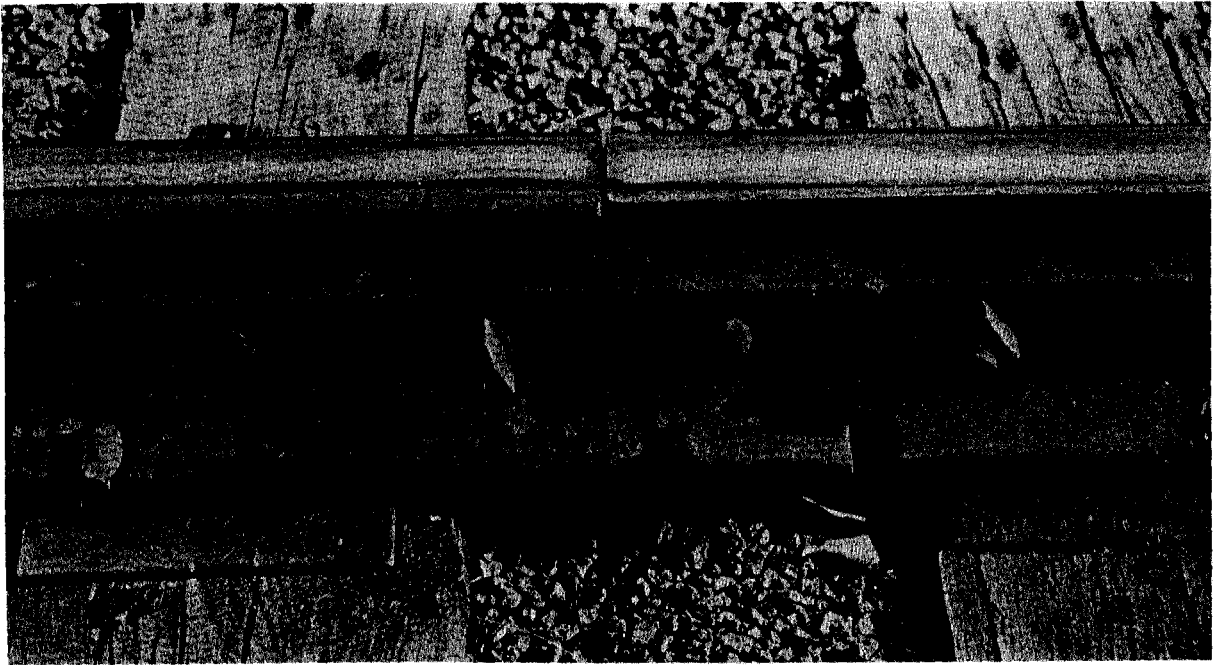


Figure 3-43. Joint-bar installation.

3-25.1.1. Keep joints tightly bolted to prevent injury to the rail ends. Use standard hand track wrenches (Figure 3-44) or a power wrench (Figure 3-45) as discussed below.

3-25.1.2. Take up wear in fishing spaces of rail and joint bars by replacing bars.

3-25.1.3. Oil all track bolts when installed and each time they are tightened. It is recommended that bolts be oiled and checked at least once every 3 months.

3-25.2. Track-Bolt Maintenance. The following practices are necessary to maintain track bolts:

3-25.2.1. In applying nuts on track bolts, the flat side of the nut should be placed next to the spring washer.

3-25.2.2. The applied bolt tension should be within a range of 20,000 to 30,000 pounds per bolt for the initial tightening and within a range of 15,000 to 25,000 pounds for subsequent tightenings. Use mechanical torque wrenches set in accordance with manufacturer's instructions.

3-25.2.3. Track bolts should be retightened as required, preferably one week and 1 to 3 months after the joint bars are applied and at intervals of 1 year thereafter. Annual retightening of bolts in paved areas may be waived based on engineering judgment and provided nondestructive tests and visual inspection are satisfactory. More frequent tightening is unnecessary and therefore uneconomical. Less frequent tightening requires too high an applied bolt tension to carry over the longer period.

3-25.2.4. Corrosion-resistant lubricant will be applied to bolt threads prior to the application of the nuts. This will reduce the variation in thread friction and promote the uniformity of tension obtained.

3-26. Compromise Joints.

Compromise joints (Figure 3-31) are used wherever rails of different weights or sections are connected. The bars must conform to the weight and section of each rail at the connection. The maintenance of compromise joints is the same as for joint bars (para 3-25).

3-27. Spikes.

3-27.1. Specifications. All spikes used for replacement, repair, and rehabilitation shall conform to AREA Standards. They must be smooth and straight with well-formed heads and sharp points and be free from nicks, cracks, or ragged edges. See Figures 2-10 and Table D-13.

3-27.2. Use. The standard 5/8- by 6-inch spike is used for all track spiking except when tracks are being shimmed. Shimmed spikes are 6 inches plus the thickness of the shim taken at 1/2-inch intervals. NOTE: Smaller spikes may be required on lightweight substandard rail.

3-27.3. Location. Location of spikes shall be in accordance with Figure 3-41.



Figure 3-44. Using a hand wrench.

3-28. Bolts, Nuts, and Lock Washers.

All joints will be fully bolted with the proper size, type, and number of bolts, nuts, and lock washers for the type of joint bar used. These items must conform to AREA criteria (see Figures 2-7 and 2-9 and Table D-13).

3-29. Rail Anchors.

3-29.1. General. Rail anchors are used in track that is subject to serious movement from rail expansion or from traffic on steep grades. They must grip the base of the rail firmly and have full bearing against the face of the tie opposite the direction of creeping. (Note rail anchors in Figure 2-11.) The following general rules apply:

3-29.1.1. At locations where rail anchors are required, ties shall be firmly tamped and fully imbedded in ballast.

3-29.1.2. When the bearing of the rail anchor has been disturbed by removal of the tie, the anchor shall be removed and reset.

3-29.1.3. Ballast should be kept away from rail anchors.

3-29.2. One-Direction Traffic. See Figure 3-46 for placement of anchors for one-direction traffic. With very few exceptions, rail creepage is in the direction of traffic. The amount of creepage will vary with the kind of ballast used and with local conditions. Figure 3-47 shows tie skewing caused by rail creepage. A minimum of eight anchors per 39-foot rail length is recommended where the need exists. Additional anchors shall be used where needed. Rail anchors shall be spaced approximately uniformly along the rail length. To avoid skewed ties, the anchors shall be applied against the same tie on opposite rails. To provide for occasional reversal of traffic and to prevent excessive opening in case of a broken rail, at least two backup anchors should also be applied per rail length and boxed in around the tie with two of the forward anchors near the quarter points of the rail.

3-29.3. Two-Way Traffic. Effective anchorage is required where track conditions indicate a need to minimize the back and forth movement of rail resulting in the churning and bunching of ties. This condition is usually caused by train movements in both directions (Figure 3-46). The use of 16 rail anchors per 39-foot rail length is recommended, eight

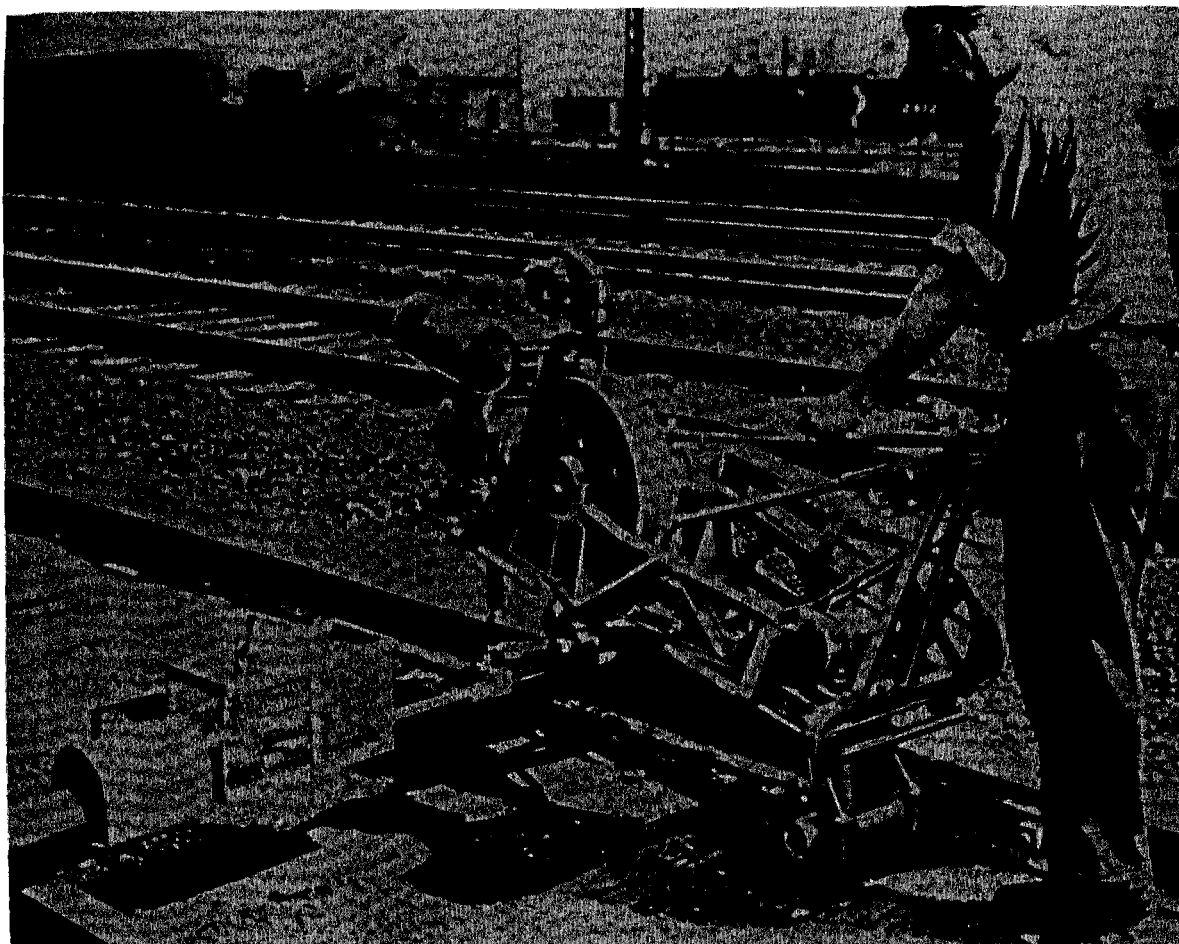


Figure 3-45. Using a power wrench.

anchors to resist movement in each direction for balanced traffic. If the traffic is much lighter in one direction, the number of anchors used to resist movement in that direction may be reduced. Additional anchors will be used where needed. The rail anchors should be spaced approximately uniformly along the rail length and against the same tie under opposite rails. The anchors to resist movement in the two directions shall be placed in pairs and boxed around the same tie. The arrangement of rail anchors for both one- and two-directional traffic is indicated in the diagram, Figure 3-46. It is important that the anchors be carefully applied and that they be in contact and remain in contact with the tie face.

3-30. Gage Rods.

Gage rods are recommended for use on sharp curves that are difficult to hold to gage, and where the track may shift because of unstable roadbed conditions.

Two to four rods are used for each rail length, applied so that the rods are at right angles to the rail and the jaws have a firm grip on the base of the rail. Some types of gage rods prevent rails from canting or tipping. Where tipping has been encountered, this combination rod shall be used to maintain alignment and gage under unfavorable conditions. Gage rods are not required with concrete ties.

3-31. Turnouts and Crossovers.

3-31.1. General. The number of the frog in a turnout designates the nomenclature of the turnout (Figure D-1) and generally establishes: (1) length of switch points; (2) lead distance; (3) radius of lead curve; (4) length of the closure rails; and (5) number, length, and spacing of ties.

3-31.2. Replacement. For purposes of maintenance, the No. 8 turnout with a straight split switch, low switch stand, and solid manganese self-guarded

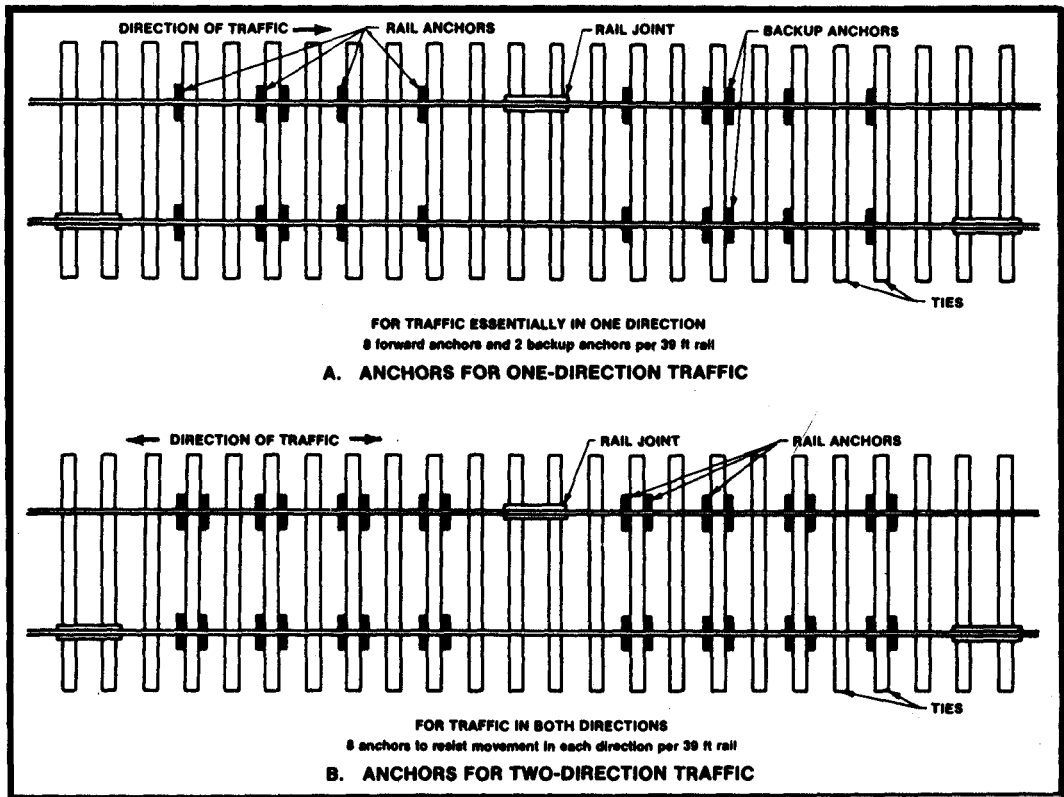


Figure 3-46. Anchor locations.

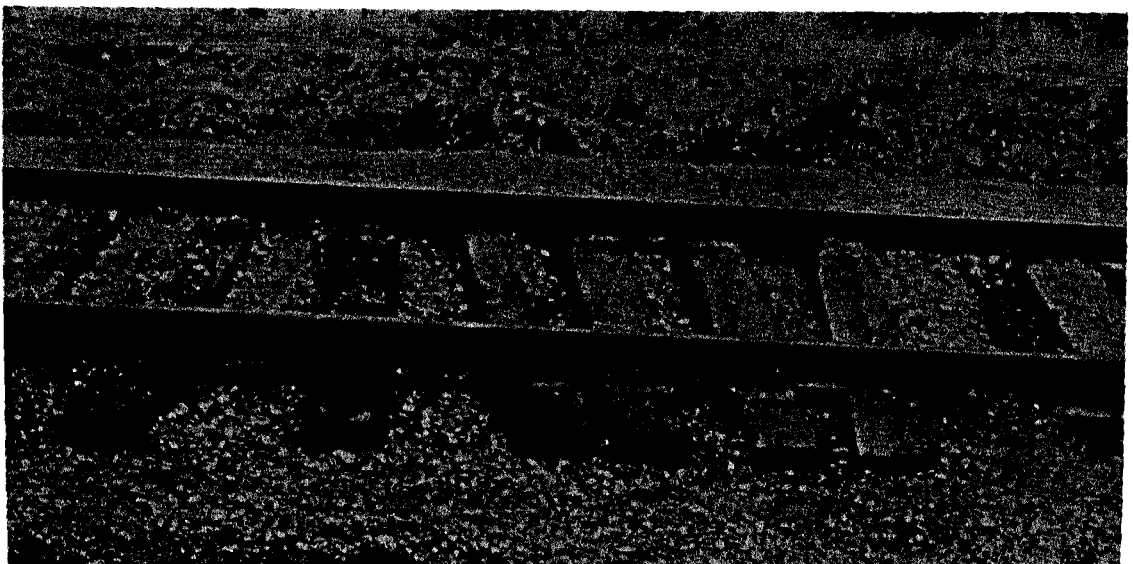


Figure 3-47. Result of rail creepage.

frog (Figure 3-48) is standard for replacement purposes wherever possible. Weight factors of switching equipment, installation layout, and site conditions must be considered in determining frog requirements. Under some circumstances, frog Nos. 7 through 10 will be needed to fit specific requirements

of installation railroad trackage. Figure 3-49 illustrates a No. 8 turnout.

3-31.3. Crossovers. A crossover consists of two turnouts with track between, and it connects two adjacent and usually parallel tracks (Figure 3-50 and 3-51).

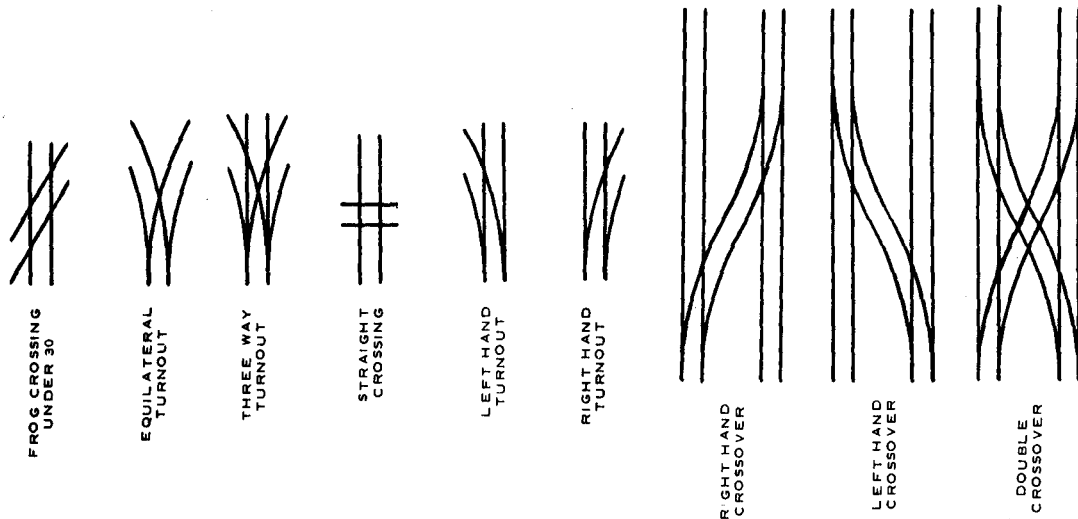


Figure 3-50. Track formations.

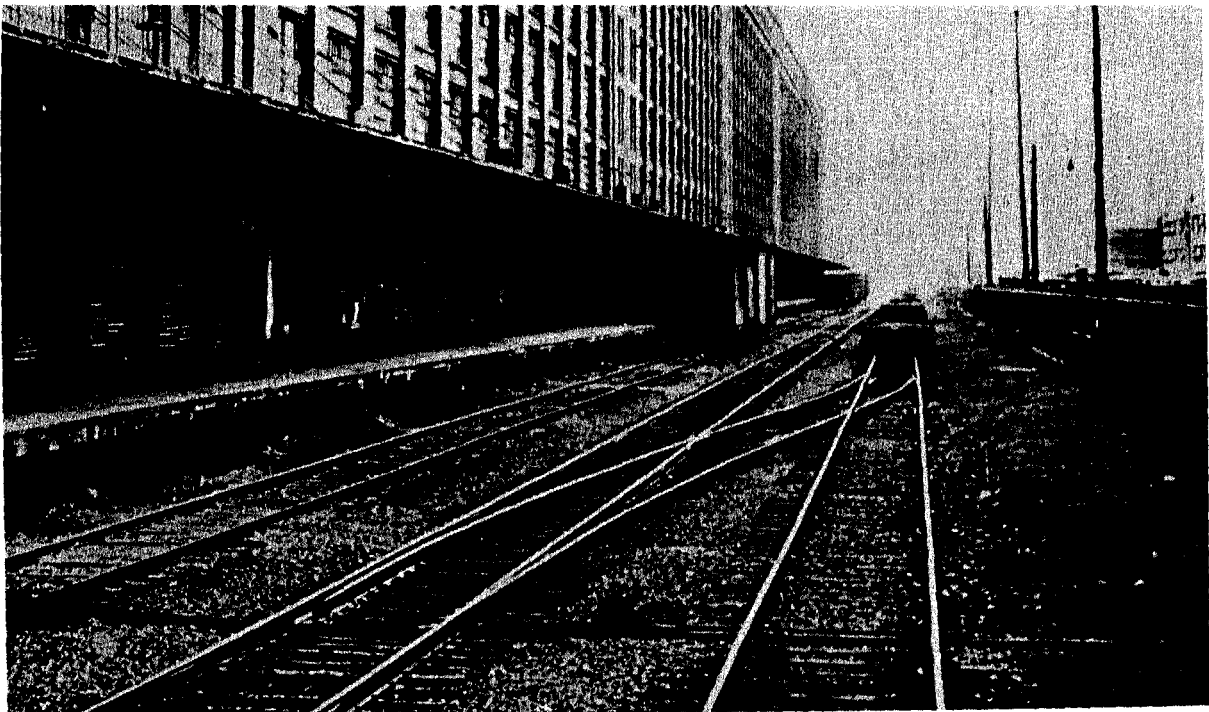


Figure 3-51. Crossover installation.

3-31.4. Location. Turnouts are located on tangent track wherever possible to minimize wear on switch points, frogs, and guardrails. When a turnout is from the inside of a curve, the degree of curvature of the turnout is approximately its normal degree plus the degree of curvature of the main line; if from the outside, the degree of curvature of the turnout is the difference between these two. Thus, if a No. 8 turnout was an angle of $12^{\circ}24'23''$ is installed on the inside of a 4-degree curve, the curvature through the turnout is equal to $12^{\circ}24'23''$ plus 4 degrees, or $16^{\circ}24'23''$. Safety against derailment and economy in maintenance require that turnouts be located so that the total curvature does not exceed 16 degrees. Figure 3-52 shows a turnout on the inside of a curve, and Figure 3-53 shows a typical ladder turnout installation.

3-31.5. Position. To facilitate switching, it is desirable that all turnouts to spur tracks lead in the same direction (Figure 3-53).

3-31.6. Switch Ties. Switch ties are of the length and spacing specified in standard plans for the turnout. Policies governing installation and maintenance of crossties apply to switch ties (para 3-10.2.).

3-31.7. Switches. Lengths of switch points adopted as standard for various turnouts are as indicated in Table 3-2. Because a loose connection or a broken connection rod is a serious defect and is likely to cause a derailment, all connecting points and connection rods require close inspection. The following instructions are supplemented and illustrated by the standard plans (Figures 3-18, 3-48, 3-49, 3-54, 3-55, and 3-56).

Table 3-2. Standard Switch Point Lengths

Number of Turnout	Length of Switch Point ft
15	22-30
12	22-30
10	15-16.5
8	15-16.5
7	15-16.5
6	11
4	11

3-31.7.1. Match switch points to weight and section of stock rail. When points are renewed, renew stock rail also, if necessary, to secure a proper fit. Connect points to the operating rod to provide ample flangeway between the open point and the stock rail. Check both switch points for this adjustment. The correct throw of the switch is $4\frac{3}{4}$ inches, with an allowable minimum limit of 4 inches or according to switch design. Mechanisms for throwing switches in paved areas should be adjusted to provide the maximum throw permitted by the equipment. Provide all

vertical bolts on switch connections with cotter pins, and place the bolts with nuts facing up. Center the slide and heel plates on the tie to provide a uniform bearing for the switch point.

3-31.7.2. If switch point protectors are used, the bolts should be checked regularly and retightened as necessary or the protector will not provide adequate protection for the switch point. When wear makes repairs necessary, manufacturer's instructions should be followed.

3-31.7.3. Check each switch to determine that it operates freely, that points fit accurately, and that rods do not foul on ties or ballast. Keep all operating mechanisms clean and thoroughly lubricated. Keep the switch free of ice, snow, and debris at all times. Frequency of switch maintenance is discussed in Chapter 7 and should be an item on the installation work plan.

3-31.7.4. Maintain surface, line, and gage throughout. Keep the gage side of the main track point in line with the gage side of the stock rail in advance of the point. Bend the stock rail with a rail bender at the proper place so that the point fits snugly against the rail when closed. Table 3-3 gives data on bends of stock rails for different lengths of switch points. Table D-1 and Figure D-1 give data regarding various turnouts. NOTE: In ground-level crane trackage switches, the rail in some switches will "bow-up." This is a "not serious" defect unless it causes binding or other difficulty in operation of the switch or the passing of a crane. Insure that ample flangeway is available between the open point of switch and the stock rail; this is controlled by flange width of crane wheels using the track system.

Table 3.3 Offsets for Bending Stock Rail

Length of Switch Point ft	Distance of Bend Ahead of Switch Point in.	Perpendicular Offset from Original Line at 10 Feet from Bend in.
30	7-3/8	1-7/8
22	5-1/2	3-1/8
16.5	3-1/4	3-5/8
15	4-1/16	3-7/8
11	5-1/2	5-5/8

3-31.8. Switch Stands. The switch-operating mechanism consists of a hand-operated switch stand with throw lever and a connecting rod. The switch stand is placed on the two 15-foot header ties at the point of switch. Where practicable, the switch stand is located on the right side of the track with respect to the normal direction of traffic. The switch stand is installed and maintained according to the following requirements:

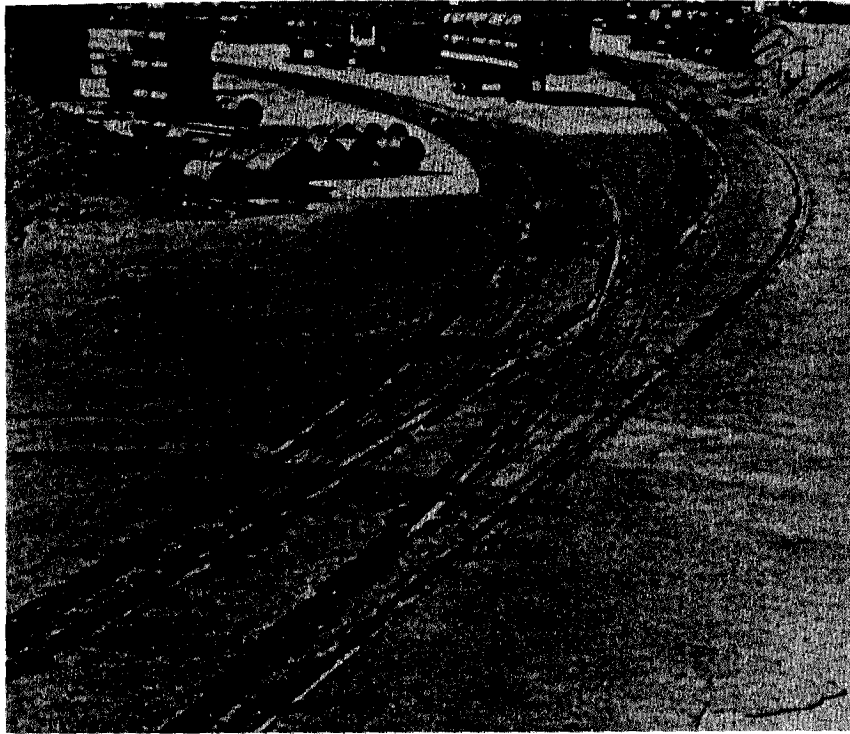


Figure 3-52. Turnout on a curve.

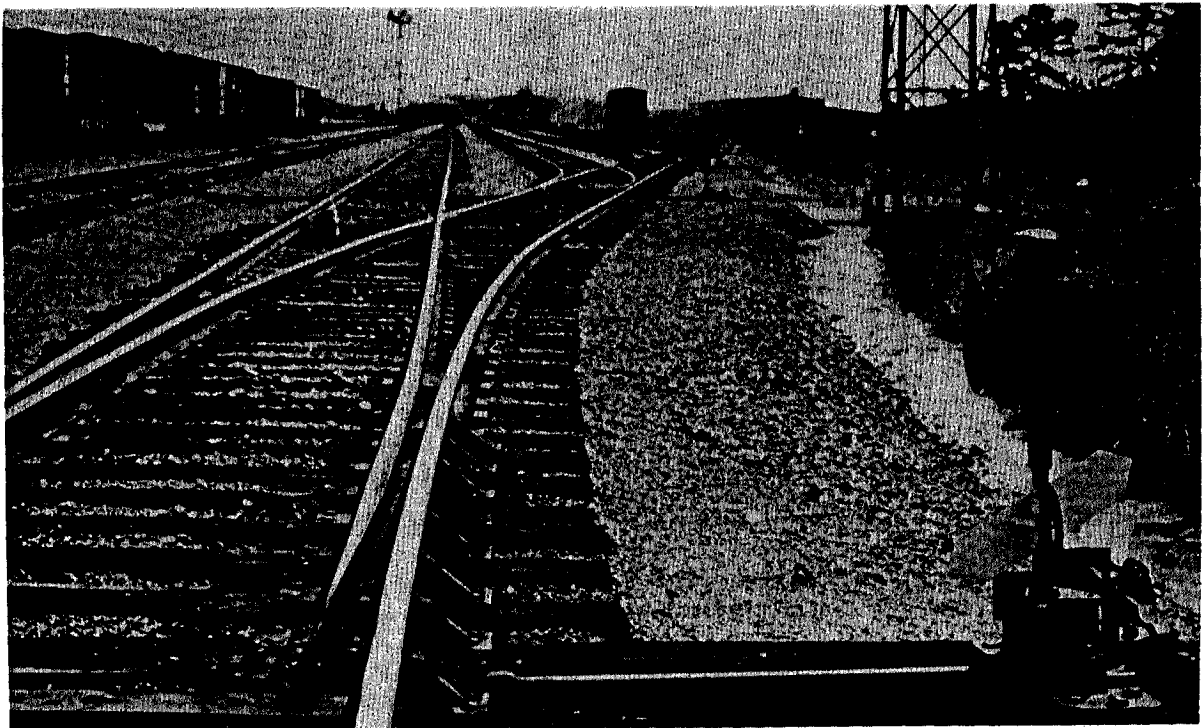


Figure 3-53. Ladder turnout installation.

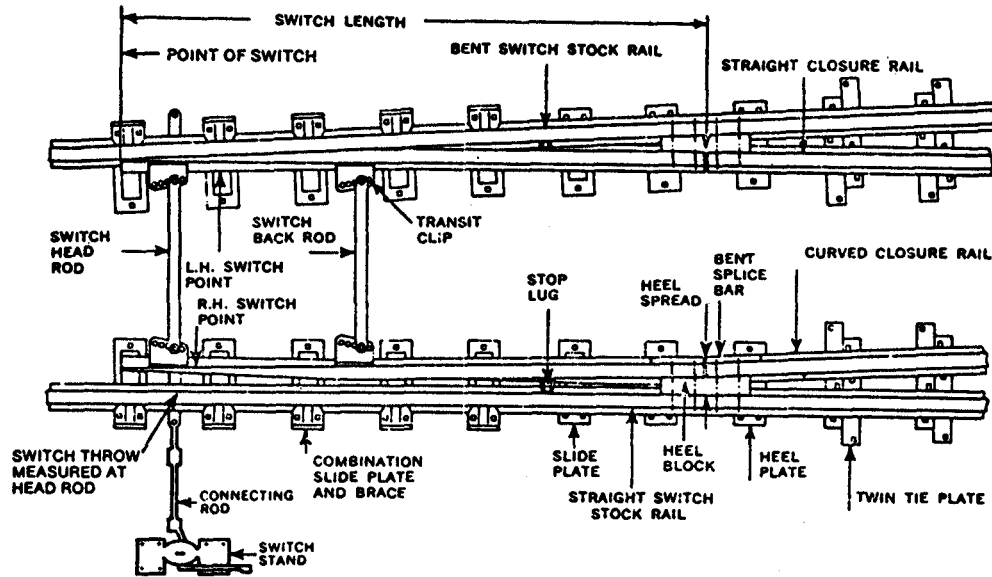


Figure 3-54. Nomenclature of switch parts.

3-31.8.1. Hand lever operates parallel to the track.

3-31.8.2. Throw of stand is adjustable from 4-1/2 to 5-1/2 inches; the adjustment is made so that each switch point has a throw of 4-3/4 inches. Throw of switch points should be a minimum of 4 inches.

3-31.8.3. Center of stand is approximately 6 feet 6 inches from centerline of track.

3-31.8.4. Colored targets and/or distinctly shaped targets are provided to indicate switch points clearly at locations where such indications are necessary. Figure 3-57 shows the type of switch stand most commonly used on military installations; it may be used in paved areas. Figure 3-58 shows the type of switch stand that clearly shows the setting of the switch by high target.

3-31.8.5. For night operations, switch targets are red and green reflectors or red and green lanterns mounted on the spindle. Green indicates switch normal and red indicates switch reversed.

3-31.9. Railroad Frogs. When necessary to purchase new frogs, the solid manganese self-guarded frogs (Figure 3-48) should be purchased; however, any supply of rigid bolted frogs on hand can be used. The above frogs should be used unless a variation is specifically authorized by a higher authority. The rigid frogs are preferred for all locations because of their maintenance free characteristics; however, the use of the turntable frog is mandatory for certain

angles below 30 degrees, depending upon frog angle, curve radius, and flangeway width of crossing rail. Existing spring rail frogs should be replaced as soon as practicable with standard rigid frogs. When using standard bolted frogs, guard rails shall be installed to protect the frog point and assist in the prevention of derailments. Railroad frogs are installed in the following manner:

3-31.9.1. The frog number corresponds to the turnout number.

3-31.9.2. The frog is of the same weight and section as the rails through the lead.

3-31.9.3. All frogs are fastened to switch ties by hook plates (Figure 3-59), fully spiked. Spikes will be kept fully driven; all bolts must be tight, and any broken bolts shall be replaced immediately.

3-31.9.4. Correct line, surface, and gage shall be maintained.

3-31.10. Guardrails. Guardrails are not required with solid manganese self-guarded frogs, except under special circumstances. Guardrails may be either 8 feet 4-1/2 inches, one-piece manganese or 9 feet 5 inches tee rail with fillers (Figures 3-60 and 3-61).

3-31.11. Guardrail Placement. Requirements for guardrail placement are:

3-31.11.1. Guardrails are placed in accordance with Figure 3-59 or 3-60, and Figure 3-62.

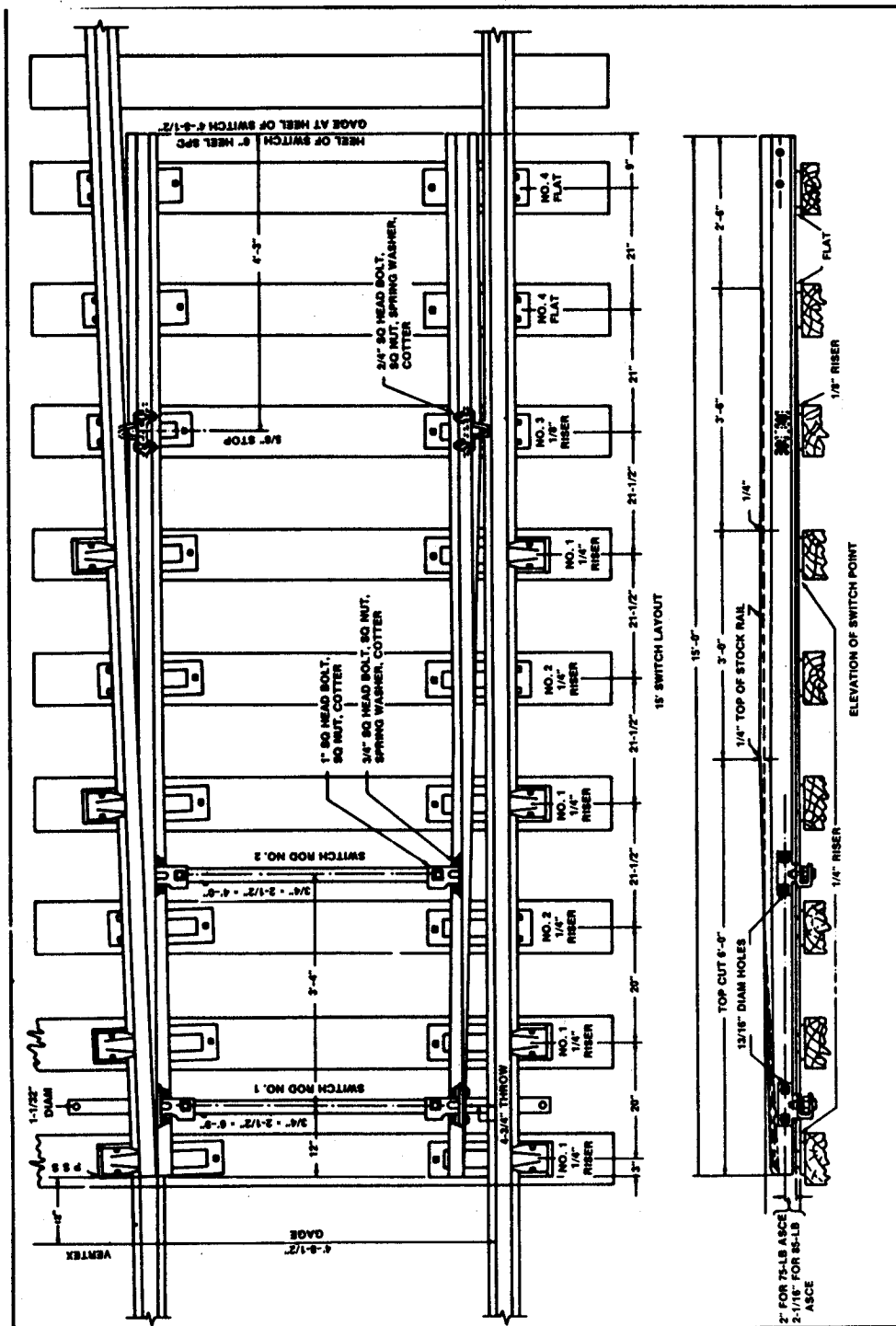


Figure 3-55. Layout and details of 15-foot switch.

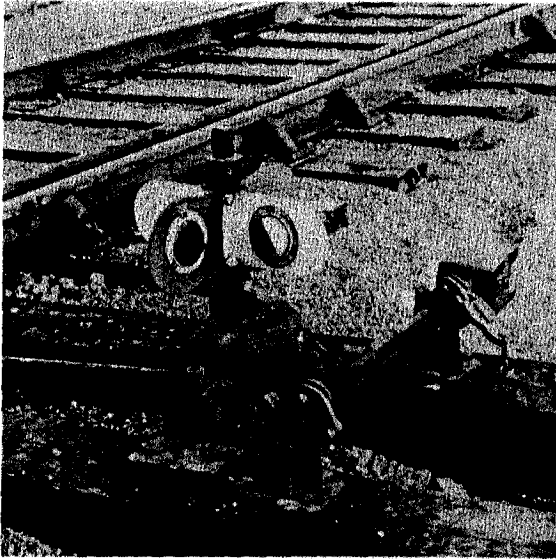


Figure 3-57. Switch stand with target.

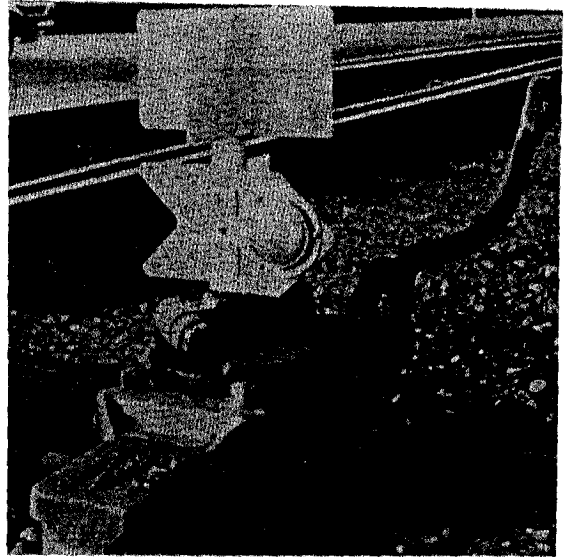


Figure 3-58. Switch stand with high target.

3-31.11.2. The gage of guardrails at frogs must be checked frequently. Normally, the distance from the gage line of the frog to the flangeway face of the guardrail is 4 feet 6-5/8 inches (guard check gage); however, if curvature through turnout exceeds 8 degrees, the distance must be 4 feet 6-3/4 inches regardless of track gage. The distance between the guard line of the guardrail and the guard line of the frog (guard face gage) should not exceed 4 feet 5 inches (Figure 3-62).

3-31.11.3. Ends of guardrails are placed on a tie or are otherwise protected to prevent loose or dragging objects from catching or fouling the rail.

3-31.12. Derails and Rerails. Derails and rerails (Figure 3-63) must be kept in good operating condition. Frequent observations should be made to see

that the clearance point has not changed because of shifting or movement of running track. Derails are painted a bright chrome yellow to make them clearly visible. Rerail devices shown in Figure 3-63 are not permanent and should not be placed in track unless needed for rerailing cars.

3-31.13. Clearance Marker. Where derails are not used, a chrome yellow strip 10 inches wide should be painted across the web and base of each rail of the connecting track at the clearance point, or other distinctive marker should be used (Figure 3-64). The markings or markers must be located at sufficient distance from cross or converging tracks to provide adequate clearance between standing or moving trains, or at road crossings to prevent standing trains or cars from fouling the intersection.

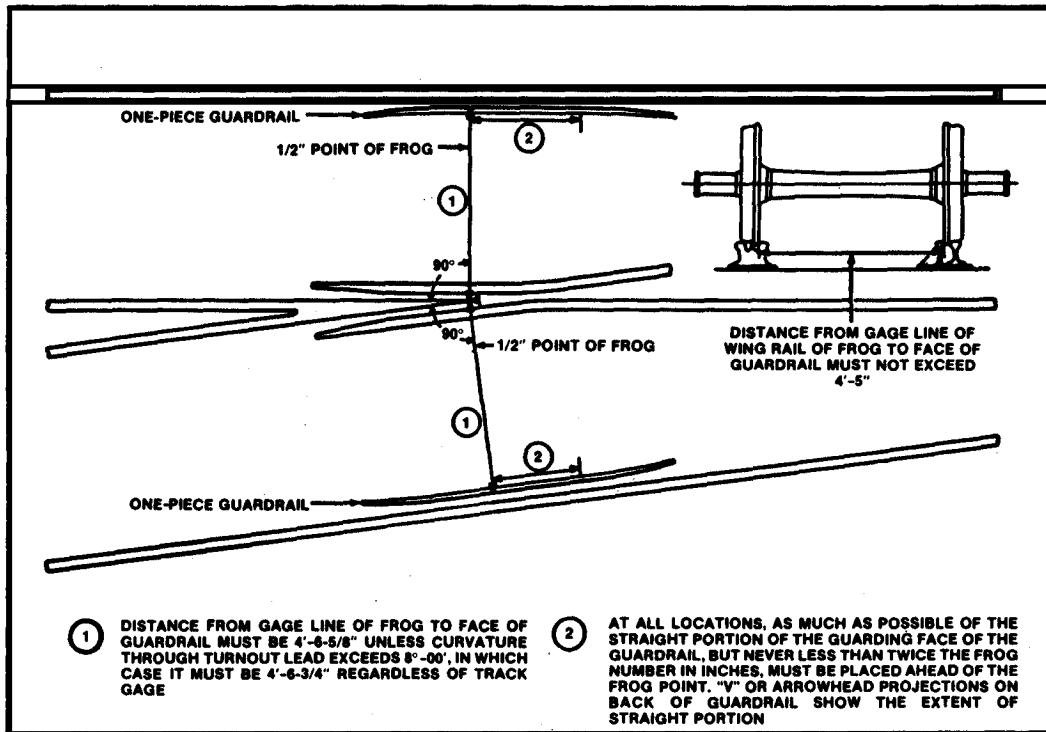


Figure 3-62. Gage at guardrails.

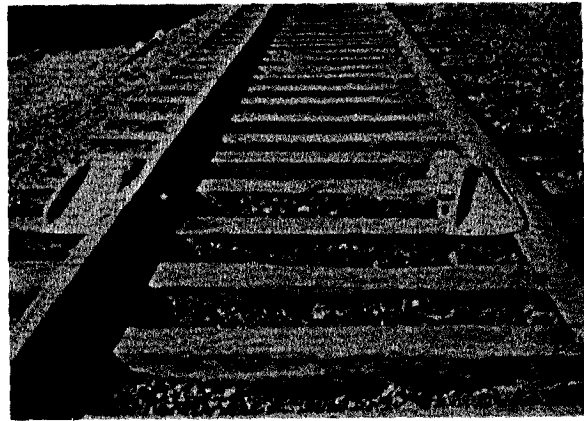
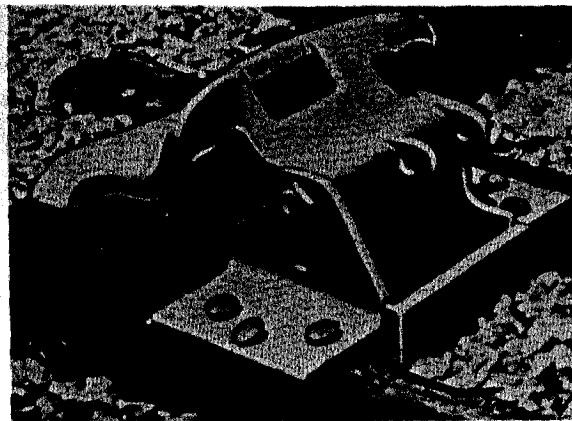


Figure 3-63. Derail (left) and rerrail installations.

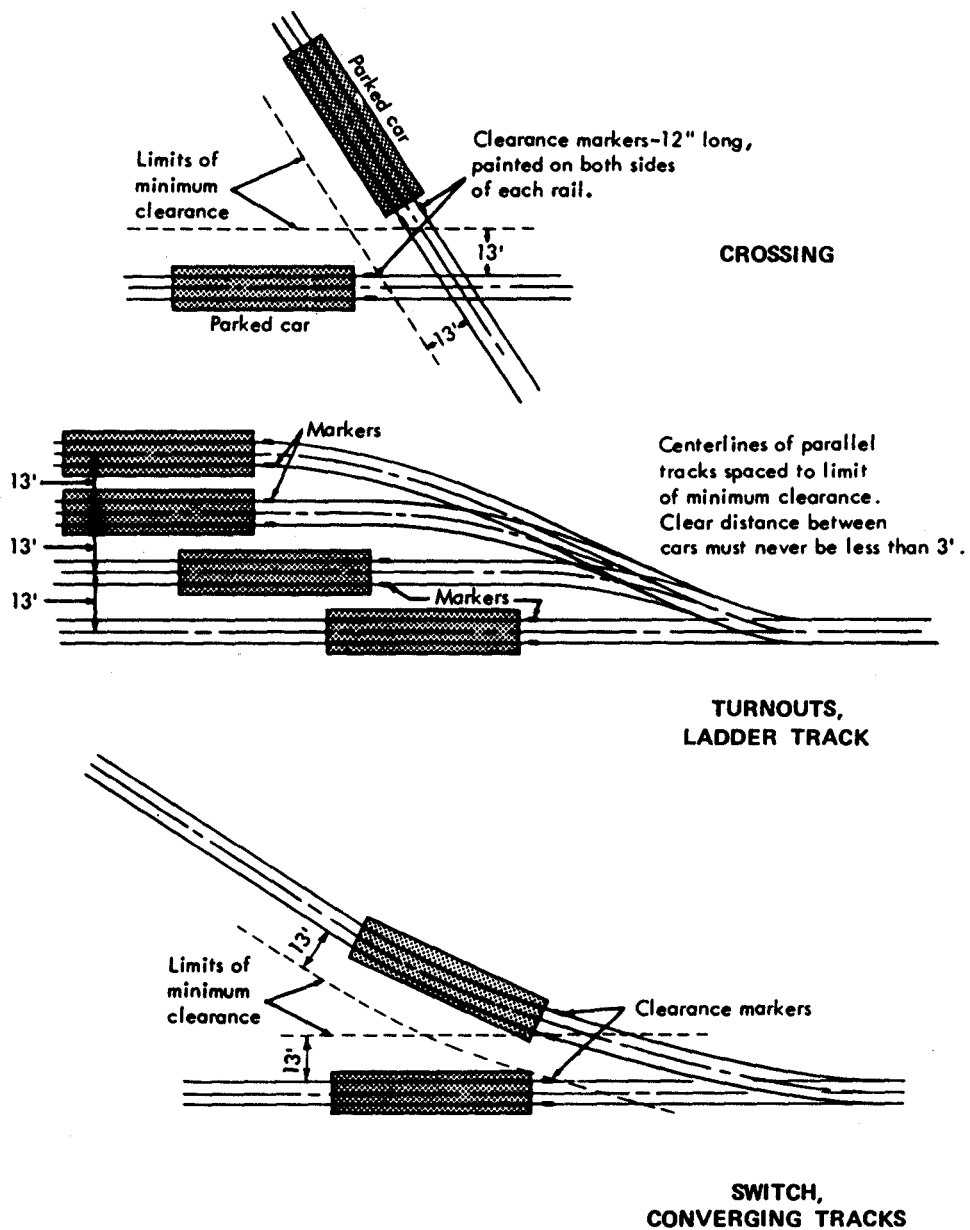


Figure 3-64. Locations of clearance markers.

CHAPTER 4.

SPECIFIC MAINTENANCE OPERATIONS

Section 1. MAINTENANCE OF TRACK

4-1. Lining Track.

Track is aligned at the same time it is surfaced. The "line" rail is always aligned and surfaced first, then the second rail. The line rail is the north or east rail.

4-1.1. Horizontal Alignment. Existing systems, not conforming to grade and curvature standards, may be maintained as is, provided a record is on file describing each deviation from the standard and necessary operating restrictions are imposed. Restrictions shall be tailored to each specific situation and may include such items as maximum speed, use of push bars, and maximum car/engine combination. To assist cars or cranes in tracking and to reduce wear on sharp or substandard curves, it is suggested that tracks be oiled. Track oilers may be installed on Government-owned locomotives operating over sharp curvatures.

4-1.1.1. Railroad trackage. All curves shall have a designated degree of curvature. Curves with radii less than 300 feet or frogs No. 4 and below shall be approved by higher authority than the installation. The radius established by the activity is the base line, design, theoretical radius, or the radius that best fits the overall existing condition. Curve alignment that deviates from established uniformity more than the amount shown in Appendix B is considered defective. Spirals, as designed or as developed, shall have a smooth transition.

4-1.1.2. Ground-Level Crane Trackage. Horizontal rail alignment of curved crane trackage shall be designed or laid out based on analyzing portal crane float requirements for traversing curved track. This analysis of required float can be compared to the float capabilities of all cranes to clearly define the problem areas. The problems may result in limited restriction of crane operation, reworking the running gear on the crane, or realigning the trackage. It should be noted that the available design float of a crane may not necessarily be operational. Curved crane trackage cannot be checked or lined using the string-line method described herein.

4-1.2. Tangents. On tangent track, the line rail is brought to correct line by eye (Figure 4-1) or by use

of a transit. The other rail is brought to line by correcting to proper gage. Figure 4-2 illustrates lining track operations.

4-1.3. Curves. Lining of track on curves is more complicated because the curve must not only be uniform throughout its length, but, in most cases, an easement (spiral) into the curve must be provided from both tangents.

4-1.3. Curves. Lining of track on curves is more complicated because the curve must not only be uniform throughout its length, but, in most cases, an easement (spiral) into the curve must be provided from both tangents.

4-1.3.1. Compound or reverse curves should be provided with easements or spirals from one curve into the other.

4-1.3.2. A transit is employed and curves are staked out in laying out new work or in making major changes to an existing track layout. A transit should be used in laying out new work or when making major changes to an existing track layout. The string-line method can also be used, but is not recommended for new work or major changes. String lining is best used for determining the degree of curvature and in locating and correcting irregularities in the alignment of curves. Field operations and methods of calculation are as given in the AREA manual and Appendix F.

4-2. Surfacing Track.

4-2.1. General. All tracks shall be laid and maintained to correct surface elevation. Surfacing out-of-face refers to raising the track structure to a new grade. Spot surfacing refers to raising low spots to the original uniform surface. Correct surfacing implies that a plane across the top of the rails at right angles to the rails is level on tangents and has the correct inclination on curves when superelevation (para D-2, Appendix D) is used. The track level is used in all surfacing work (Figure 4-3).

4-2.1.1. Pay special attention to surface and line of track at ends and approaches to bridges, trestles, and culverts; through turnouts and crossings; and at platforms.



Figure 4-1. "Eyeballing" track.



Figure 4-2. Operation of lining track.

4-2.1.2. Work against the current of traffic when raising track, except on heavy grades where it is desirable to work upgrade.

4-2.1.3. Before raising track during hot weather, be sure that rails will not warp or buckle. Consider the amount of rail openings at joints, tightness of bolts, position of rail anchors, and amount of ballast in cribs and at ends of ties. Where there is danger of buckling, loosen track joints in both directions from the danger point to allow for expansion.

4-2.1.4. In bonded-track territory, see that ballast clears the base of the rail to prevent leakage of current. Separate ballast and base of rail by a space of about 2 inches.

4-2.2. Grade. Profile grades shall not exceed the design grade except as noted below.

4-2.2.1. Railroad Trackage. Grades may be spot checked at random intervals with a hand level and rule. All grade changes shall be connected with a vertical curve. Switches may be installed on grade; however, no part of the switch should extend into a vertical curve.

4-2.2.2. Ground-Level Crane Trackage. On existing trackage with grades in excess of 1 percent, if cranes do not encounter acceleration or deceleration

problems in traversing the tracks, no action is required. However, if problems are apparent or if other deficiencies dictate complete replacement of the track, the criteria of 1 percent maximum grade shall be followed. Curves, switches, and frogs shall be on a level grade in order to minimize the possibility of derailment. NOTE: If existing grade is not level or if there is a difference in elevation of 1 inch between the inside rail and the outside rail, crane float shall be analyzed to determine whether the wheel flanges will clear the rail and permit the truck assembly to swivel and cause derailment. Observing the position of the wheel flanges in relation to the top of the rail will reveal areas that may become critical. If wheel flanges clear the top of the rail, extreme caution must be taken during operations and immediate action initiated to correct the deficiency. The area in question should be classified as critical and well marked so that all crane operators and crews will be cognizant of the deficiency.

4-2.2.3. Elevated Crane Trackage. The rail should be kept near level grade. The rail gradient must be kept below the slope that will cause the crane to roll freely and present problems in starting or stopping the crane.



Figure 4-3. Surfacing track with a leveling beam.

4-2.3. Cross-Section Elevation. Vertical differences between rails shall be within the limits shown in Appendix B.

4-2.3.1. Railroad Trackage. On curved trackage with designed superelevation, the outside rail shall not be lower than the inside rail and the maximum cross-section elevation differences shall be within the limits shown in Appendix D for the designed superelevation based on degree of curvature and speed. On curved trackage in industrial areas traversed at low speeds, superelevation is not required.

4-2.3.2. Ground-Level Crane Trackage. When the difference in elevation between the elevation of the inside rail and the outside rail exceeds 1 inch, the crane float shall be analyzed and appropriate action taken.

4-2.3.3. Elevated Crane Trackage. The cross-sectional difference in elevation of rails shall not exceed the limits established by the activity based on engineering judgement for each specific trackage system or the tolerance recommended by the manufacturer when known.

4-2.4. Hand Jacking. There are two methods of surfacing track with track jacks: one is used where the lift is less than 2 inches, and the other where the lift is more than 2 inches. The two methods are discussed below:

4-2.4.1. In starting a raise or lift of less than 2 inches, jacking points should be spaced 8 to 12 feet apart. Place the first jack approximately 10 feet ahead of starting point of the raise. Place the second jack 10 feet ahead of the first jack. Raise both jacks to give an even grade from the starting point to the second jack. Tamp the ties to a point approximately halfway between the jacks. Bring the other rail to proper surface with the aid of the track level. Then move the first jack about 10 feet ahead of the second, raise the rail at that point, and tamp the ties halfway between the jacks. Follow the same procedure to bring the other rail to proper surface, using the track level to determine the amount of lift.

4-2.4.2. To lift the track more than 2 inches, locate both jacks as above, but reduce the spacing between jacks to avoid permanent bending of the rail. Raise the first jack to bring the rail to grade between 0 and 1. Then raise the second jack enough to provide reasonable runoff between the new grade and the low spot. Tamp ties to a point approximately one-fourth the distance between 1 and 2. Raise the second jack to bring the rail to proper grade, and move the first jack ahead the proper spacing. Tamp as before, and continue the same operations through the full length of track to be raised.

CAUTION: In both methods, jacks must be placed ahead of rail joints to prevent strain on joint bars (Figure 4-4).

4-2.4.3. In raising or surfacing track, the inner rail on curves and the line rail on tangents are the grade rails. Bring them to surface with the aid of the spot board, or refer them to grade stakes. Bring the second rail to surface with the aid of the track level.

4-2.4.4. Bring both rails to grade, tamp ties, set tie plates, gage track, and drive spikes fully before jacks are moved ahead.

4-2.4.5. Place track jacks in cribs between the ties outside the rail, and set them true vertically. If jacks are to be placed between rails, set them in trip position, and provide flag protection.

4-3. Tamping.

Systematic and uniform tamping is of great importance in maintaining correct surface and line. See Figures 3-7 through 3-9 and paragraph 3-6.3.

4-3.1. Tools. Pneumatic, electric, gasoline, or other mechanically operated or hand tampers may be used for tamping. The type of tool varies somewhat for different materials as follows:

4-3.1.1. For broken stone, crushed and washed gravel, or slag ballast, use a tamping pick or bar, ballast spade, or power tamper. Power equipment will be fitted with a tool having an end similar to a tamping pick face or vibratory tool.

4-3.1.2. For gravel, chats, or chert ballast use a shovel, ballast fork, ballast spade, tamping pick, tamping bar, or power tamper. For heavy traffic, a tamping pick, tamping bar, or power tamper should be used. With a power tamper use a tamping tool with a tamping end of sufficient area. For light traffic, shovel tamping is sufficient.

4-3.1.3. For spot tamping, tamping picks, ballast forks, ballast spades, shovels, tamping bars, or power tampers may be used.

4-3.2. Methods. After the track has been raised on jacks to a true surface, pack ballast firmly under the ties. Tamp so that a tight bearing is obtained between the tie and the raised rail, but without disturbing the surface. The following tamping methods apply:

4-3.2.1. Tool Positioning. Regardless of the kind of ballast or the kind of power tamper used, two tamping tools must always be worked opposite each other on the same tie. Start power tampers from a vertical position, and use them directly against the sides of the tie to be tamped. Work downward past the bottom corner, after which the tools may be tipped down to force the ballast directly under the tie.

4-3.2.2. Tamping Distances. In tamping ties, 8-foot crossties should be tamped from 12 inches inside the rail to the end of the tie, 8-foot 6-inch crossties should be tamped from 15 inches inside the rail to the end of the tie, and 9-foot crossties should be tamped from 18 inches inside of the rail to the end of the tie.

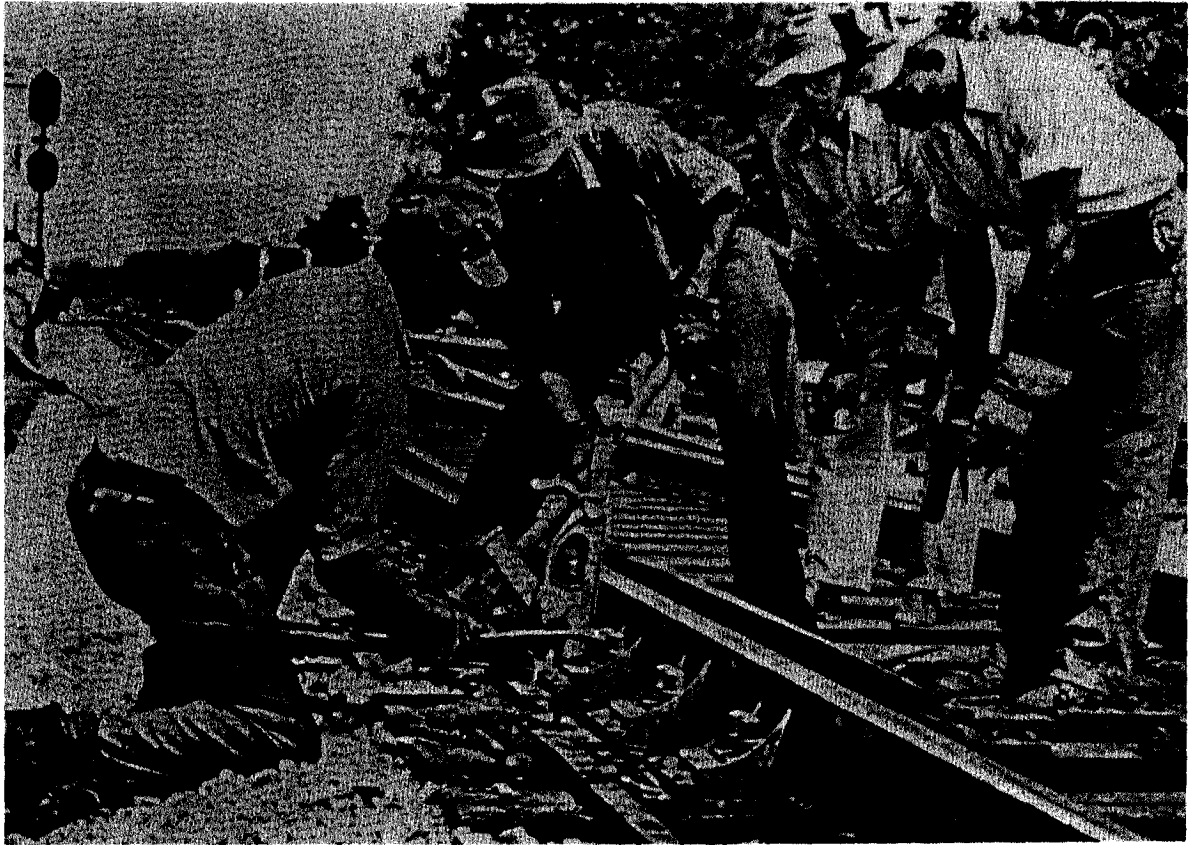


Figure 4-4. Jacking rail.

4-3.2.3. Cautions. Omit tamping at the center of the tie, between the above stated tamping limits, but this center area should be filled lightly with a ballast fork. Both sides of the ties must be tamped simultaneously, and tamping inside and outside the rail should be done at the same time.

4-4. Gauge Measurements.

Check gage of track at least annually and more frequently when the volume of traffic or local conditions warrant. Gage for railroad trackage is measured between the heads of the rails at right angles to the rails in a plane $\frac{5}{8}$ inch below the top of the railhead. Gage for crane trackage is measured center to center of railhead.

4-4.1. Railroad Trackage..

4-4.1.1. Tangent Tracks and Curves. The standard gage of 4 feet 8-1/2 inches is used for tangent track and on curves up to 8 degrees (Figure 4-5). On curves over 8 degrees, the gage is increased 1/8 inch for each increment of 2 degrees to a maximum of 4 feet 9-1/2 inches, by moving the inside roll. The rate of change from standard to widened gage is 1/4 inch in 31 feet along the spiral curve or tangent adjacent to the

curve, unless physical conditions do not permit the normal transition. The 1/4 inch in 31 feet rate of change from standard gage to widened gage for curves is a design standard and not trackage inspection criteria.

4-4.1.2. Turnouts and Crossovers. At turnouts and crossovers on curved track, the gage of the parent track is determined from the degree of curve, as described above. The degree of the turnout curve is determined by the algebraic sum of the two curves, i.e., curve of the turnout plus or minus the curve of the main track (para 3-31.4.), and the gage adjustment is made accordingly.

4-4.1.3. Ground-Level Crane Trackage. The gage on curved trackage shall under no circumstances require more lateral float than the crane can provide.

4-4.1.4. Elevated Crane Trackage. The gage of trackage shall be held within the tolerances specified by the crane manufacturer or as computed from the existing crane wheel spacing.

4-4.2. Limiting Factors for Corrective Maintenance. Variations in gage within the limits shown in Appendix B are acceptable, provided there are no alignment, attachment, or foundation defects which

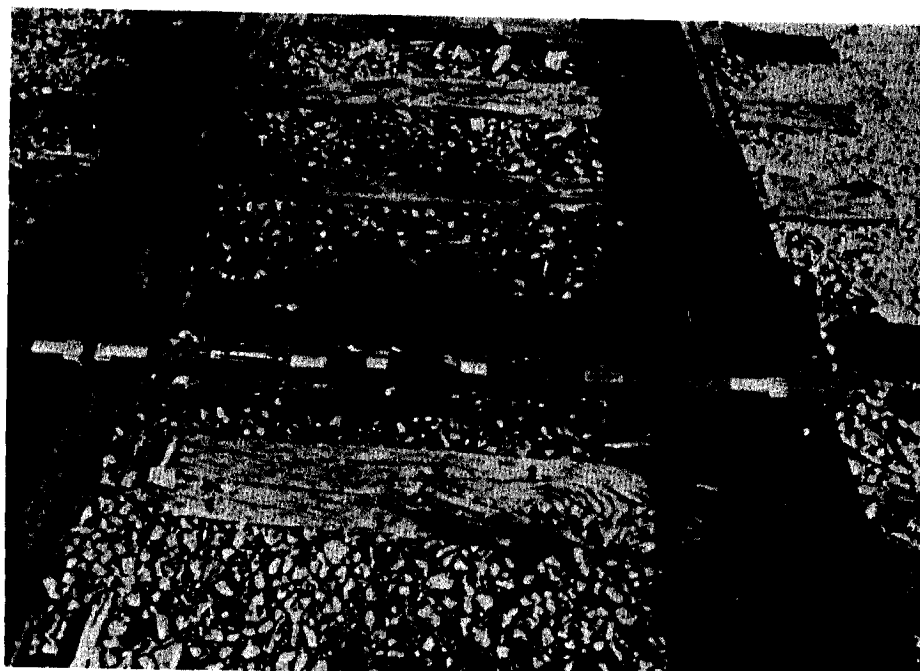
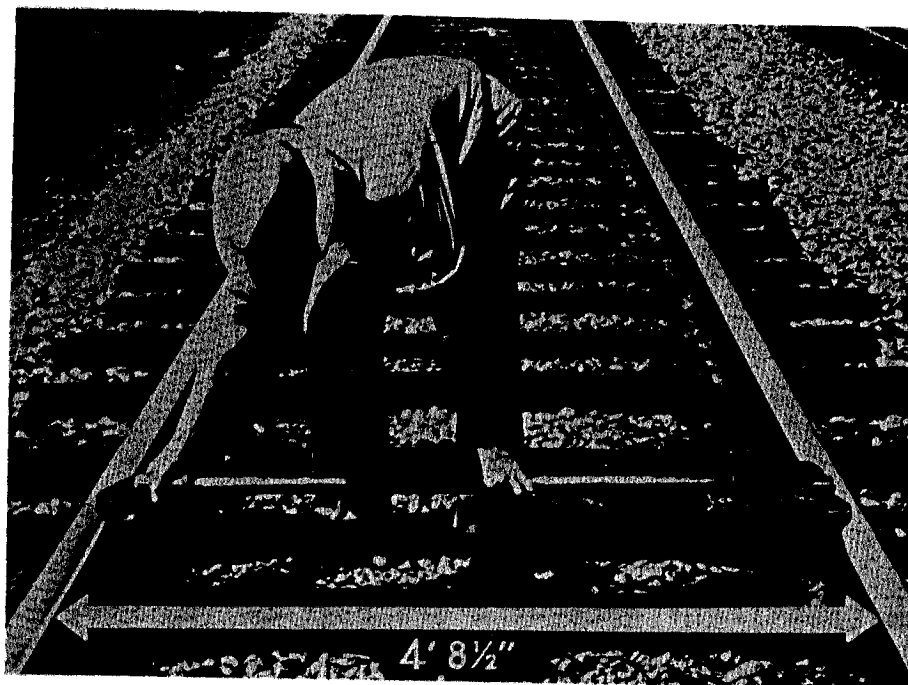


Figure 4-5. Gaging track.

would cause the train to start excessive or abnormal rocking or bouncing. Variations in gage and wide gage transitions are not serious provided the changes are relatively uniform and constant over two standard rail lengths, the fastenings secure, and the alignment within prescribed limits. Wide gage, caused by worn rail should be corrected by closing in or by interchanging the low and high rails.

CAUTION: Interchanging the low and high rails can cause failure due to the change in stress location.

4-4.3. Procedure for Regaging. The standard track gage is used in correcting gage. It will be checked frequently and replaced when it shows a variation of 1/8 inch or more. All spike pulling and driving is done on the rail opposite the line rail. The gage is not removed until all spikes have been driven. Spikes are pulled with the standard claw bar (Figure 4-6) or spike puller (Figure 4-7). At switches, frogs, and guardrails, where the claw bar will not fit between rails, the spike puller extension is used. Creosote-treated tie plugs are driven in all spike holes before respiking. Corrections to gage shall not be made by striking the head of the driven spike toward the rail. Spikes shall be removed, rail lined to gage, and spikes redriven.

4-5. Spiking.

Spiking will follow the standards set forth in paragraph 3-21, steps h through k.

4-6. Rules for Turnout Installation.

See paragraphs 2-2 and 3-31 for general discussion and Figures 2-1 through 2-14 for descriptions. Turnouts, crossovers, and their appliances are placed and maintained in accordance with standard plans and the following rules:

4-6.1. Locate point of frog and point of switch.

4-6.2. Relocate any main-track rail joints that come within the limits of switch point or guardrail.

4-6.3. Cut the lead rails, bearing in mind that the turnout lead is longer than the main-track lead.

4-6.4. First, put in headblocks and gage plate or two side plates, then all ties for the switch point and frog, and their slide plates, braces, heel plates, and guardrail plates. The plates and braces for the unbroken line or rail are lined and fully spiked in position, whereas those on the turnout side are held in place temporarily.

4-6.5. Bend a rail for the turnout stock rail according to the data shown in Table 3-3, paragraph 3-31.7.d.

4-6.6. Couple the stock rail, main-track switch point (heel block to be placed later, if used), lead rails, and frog, on the ends of ties on the turnout side, doing such cutting and drilling as may be necessary to complete the main track from the point of the switch to the heel of the frog.

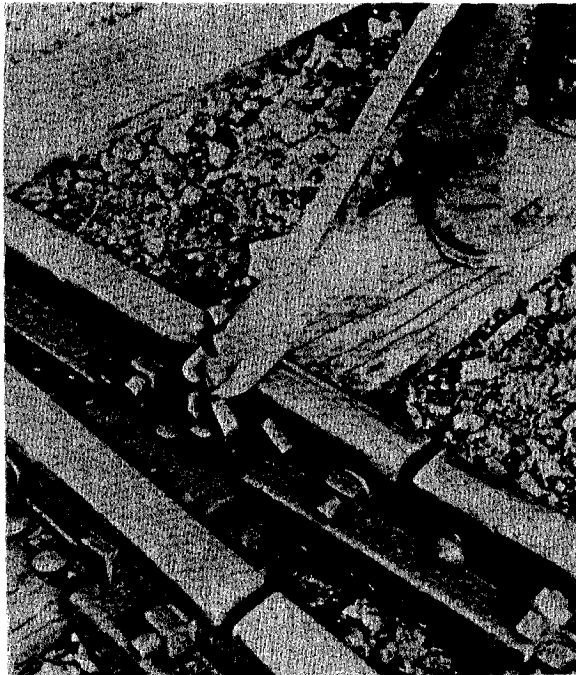


Figure 4-6. Pulling spikes with a claw bar and extension.

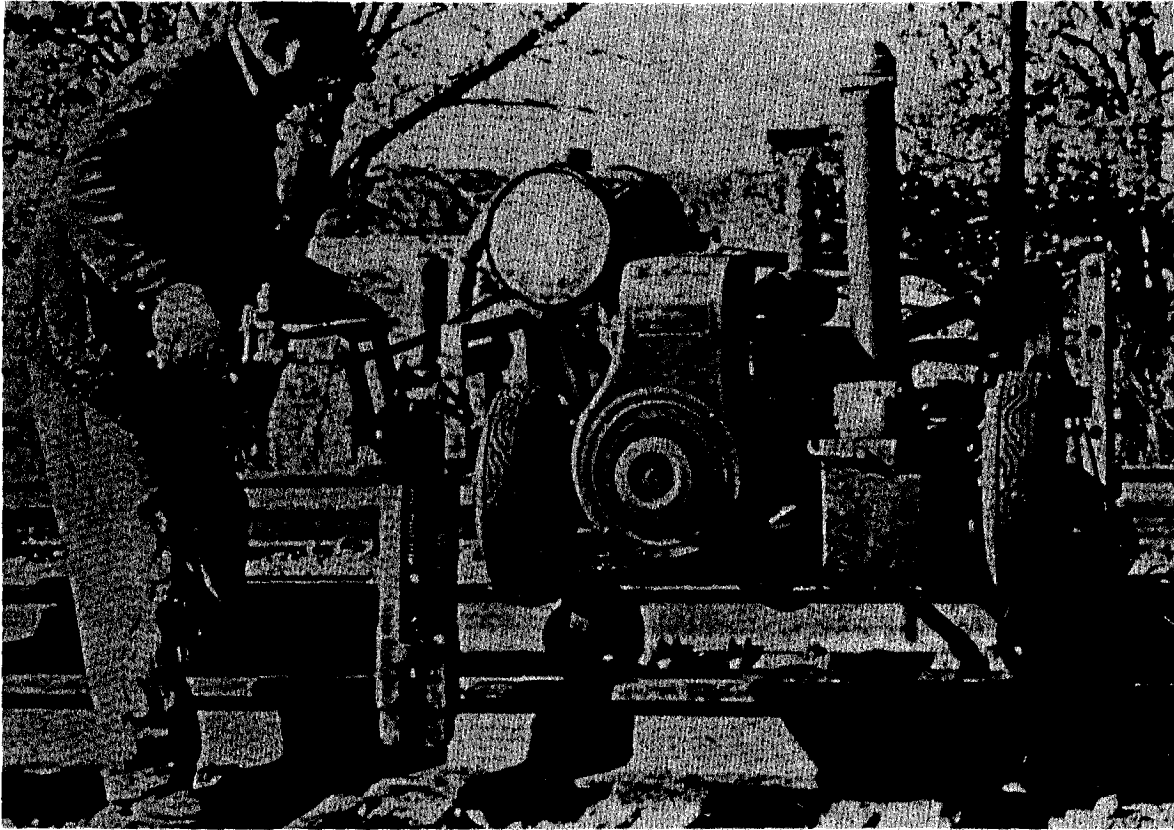


Figure 4-7. Power operated spike puller.

4-6.7. Take out the old main-track rail; set in the turnout parts in the following order: (1) place stock rail and switch point, (2) place the lead rail and frog, (3) make connections at the heel of the frog and at the stock rail, (4) spike frog to exact gage at the heel and the toe point, (5) place joint bars and tighten bolts, and (6) complete spiking from the frog to the heel of the switch point.

4-6.8. Do not permit train movement over main track until the guardrail has been correctly placed and spiked, all switch plates on the turnout side have been fully spiked in correct position, the switch point has been spiked against the stock rail, and the free end of the stock rail fastened to prevent movement.

4-6.9. In applying the switch plates on the turnout side: (1) see that gage is correct 12 inches ahead of switch point, and (2) put slide plates on tie where switch point begins to taper.

4-6.10. Adjust stock rail so that it does not bind against switch point and cause it to open. (To test this, operate the switch point and see that point touches the stock rail first.) Spike these slide plates, install and spike remaining slide plates and braces, working each way from the center.

4-6.11. When putting on slide plates, use a bar (not a pick), and do not attempt to draw the gage with a spike.

4-6.12. Put in the remaining switch ties, and line and surface main track.

4-6.13. Couple switch point for the turnout lead, set lead rails, and spike turnout lead to proper line for turnout curve.

4-6.14. Complete the work by setting the remaining guardrail (and switch-point guardrail if staggered switch points are installed), setting and adjusting the switch-operating mechanism, checking the line, gaging, spiking, and surfacing.

4-7. Shimming Track.

4-7.1. General. Heaving of track in winter and spring months is generally an indication of poor drainage or poor ballast conditions, which must be corrected as soon as frost leaves the ground. Until the cause can be eliminated, heaving can be corrected temporarily by using shims to raise the rails on either side of the high spot, thus providing an easy grade (Figure 4-8). The length of this temporary raise is

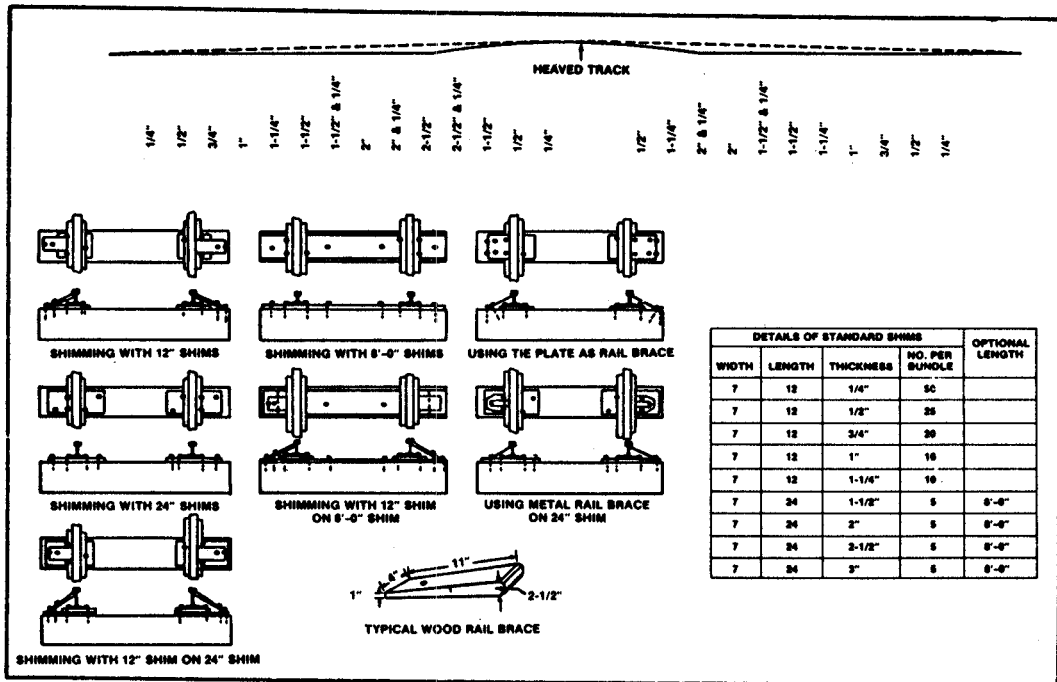


Figure 4-8. Application of wood shims and rail braces in shimming track.

called the runoff. **NOTE:** Criteria for maximum runoff are contained in Appendix B.

4-7.2. Methods. When shimming is necessary, it will be done so as to provide easy and safe runoff gradients. When one side of the track is heaved more than the other, proper cross level will be restored when shims are installed; care must be taken on curves to maintain proper curve elevation. Heaved ties will not be adzed or otherwise cut to lower their height; shimming under ties is prohibited except in an emergency, in which case the shims shall be removed, and the condition otherwise taken care of as soon as possible.

4-7.3. Rules for Shimming and Bracing. When installing shims, the track level and gage will be used to insure proper gage and surface.

4-7.3.1. Before a shim is placed on a tie, all spike holes in that tie must be plugged with treated wood tie plugs, the tie shall be free of ice, snow, and other obstructions within the area of the shim, and full bearing of the shim on the tie shall be provided.

4-7.3.2. Two shims of the same length will not be used together under one rail on a tie. One 12-inch shim may be used on top of a 24-inch or on top of a 3-foot 6-inch shim. One 24-inch shim may be used on top of a 3-foot 6-inch shim. One 24-inch shim may be used on top of a 24-inch shim that has been placed on top of

a 3-foot 6-inch shim. Where possible, use only one shim. Where two shims are required, the lower shim must be of maximum thickness. Where three shims are required, the two lower shims shall each be of maximum thickness.

4-7.3.3. When tie plates with special shallow base patterns or with shallow ribs on their bases are in use, they should be installed on top of shims. When tie plates with deep ribs on their bases are in use, they should not be installed on top of shims. Shims shall never be installed on top of tie plates.

4-7.3.4. In all cases where a 12- or 24-inch shim, or a 12-inch on top of a 24-inch shim, is installed, all spikes used shall be long enough to provide a minimum penetration of 4 inches in the tie. In all cases where a 3-foot 6-inch shim is installed, it will be properly and independently spiked to the tie with 7-1/2-inch shimming spikes. In all cases where a 12- or 24-inch shim is installed on top of a 3-foot 6-inch shim, all spikes through the shorter shims shall be long enough to go through the 3-foot 6-inch shim and have a minimum penetration of 1 inch in the tie.

4-7.4. Precautions.

4-7.4.1. Driving shims at an angle between the spikes weakens the track and is prohibited. Shims shall be placed squarely on top of the tie and the spikes driven through the holes provided.

4-7.4.2. Wood or other types of rail braces should not be used where shimming is done on tangent track or on curved track equipped with shoulder tie plates of a type that is to be used on top of shims. Where shimming is done on curved track not yet equipped with tie plates, or equipped with shoulder tie plates of a type that will not be used on top of shims, wood or other approved rail braces shall be installed with the shims.

4-7.5. Reestablishing Normal Surface. As the frost leaves the ground and the heaved places return to their proper level, the shimming may be reduced from time to time in order to maintain proper surface. When the frost has left the ground, all shims shall be removed without delay from the track and any imperfect surface corrected. Removed shims and shimming spikes should be carefully preserved for future use.

Section 2. MAINTENANCE OF TRACK IN STREET CROSSINGS AND IN PAVED AREAS

4-8. General.

Prompt attention must be given to correcting deficiencies as they occur at crossings and around tracks in paved areas. The maintenance of the track bed and trackage will be the same as that outlined in the foregoing chapters and sections, except that inspection will be more difficult and additional maintenance is required for the paving, planking, etc., to insure smooth and safe operation of vehicles in the area. Because track maintenance in paved areas is more costly and time consuming, materials supporting and contained in the track structure must have as low a maintenance potential as possible. For that reason, materials that will resist deterioration and changes in grade and gage are recommended.

4-9. Drainage.

Drainage is critical. It can present more problems at crossings than at other points on a railroad. Catch-basins, gutters, ditches, pipe drains, and/or culverts, as appropriate, must be provided to intercept and divert both surface and subsurface water at depressed or downhill crossings. Base materials underlying tracks and pavement must be of appropriate, well-graded, granular materials; pavement surfaces must be adequately crowned and sloped to direct water into the catch-basins and ditches. Additional information on drainage is included in Section 3 of this chapter.

4-10. Ballast.

Ballast under a properly maintained pavement or crossing normally requires little or no maintenance. However, if the ballast is not installed properly on a good foundation in the beginning, or if the surface over the ballast permits infiltration of water, silt, and other debris, the ballast can become fouled and interfere with the drainage. If the track through the crossing is not well ballasted, or if the ballast is fouled, the ballast and subballast should be removed not less than 2 feet below the bottom of the ties, not

less than 2 feet beyond the ends of the ties, and to the first rail joint away from the crossing and replaced in accordance with criteria set forth in Chapter 3, Section 2.

4-11. Ties.

The condition of cross-ties under crossings or pavement cannot be determined without removing the crossing materials or paving. If untreated ties were originally installed, they may be seriously damaged by insect attack or decay in a short period of time (Figure 4-9). The first indication of tie failure may be settling of the rails or paving or a change in track gage. When tracks are torn up to replace the ties, it not only interferes with train operations, but also with the use of the area or crossing by vehicular traffic. When the trackage has been uncovered for repairs, the whole trackage system in the crossing or paved area should be brought up to proper condition. Drainage and ballast should be investigated and replaced or restored before the new ties are installed. Also, all the ties should be replaced at this time. Normally, 9-foot treated wood ties are used through the limits of a crossing. However, concrete ties should be considered when replacement is needed because they require little or no maintenance and hold the track in gage.

4-12. Rail.

As a general rule, bolted rail joints are not allowed within a crossing. Where crossing widths and rail lengths are such that joints have to be included, they shall be properly welded. The nearest bolted joints should be at a minimum of 6 feet outside of the crossings. Every precaution must be taken to insure adequate and continuing bonding of rail through the crossing. All rail and metal fittings used within a crossing shall be given a coating of an approved rust inhibitor. Rail shall be gaged and lined accurately and double spiked to the ties. The ballast under the track shall be solidly tamped to bring the track to grade. If concrete ties are used, the rails will be firmly bolted to the ties and the track then brought to grade.

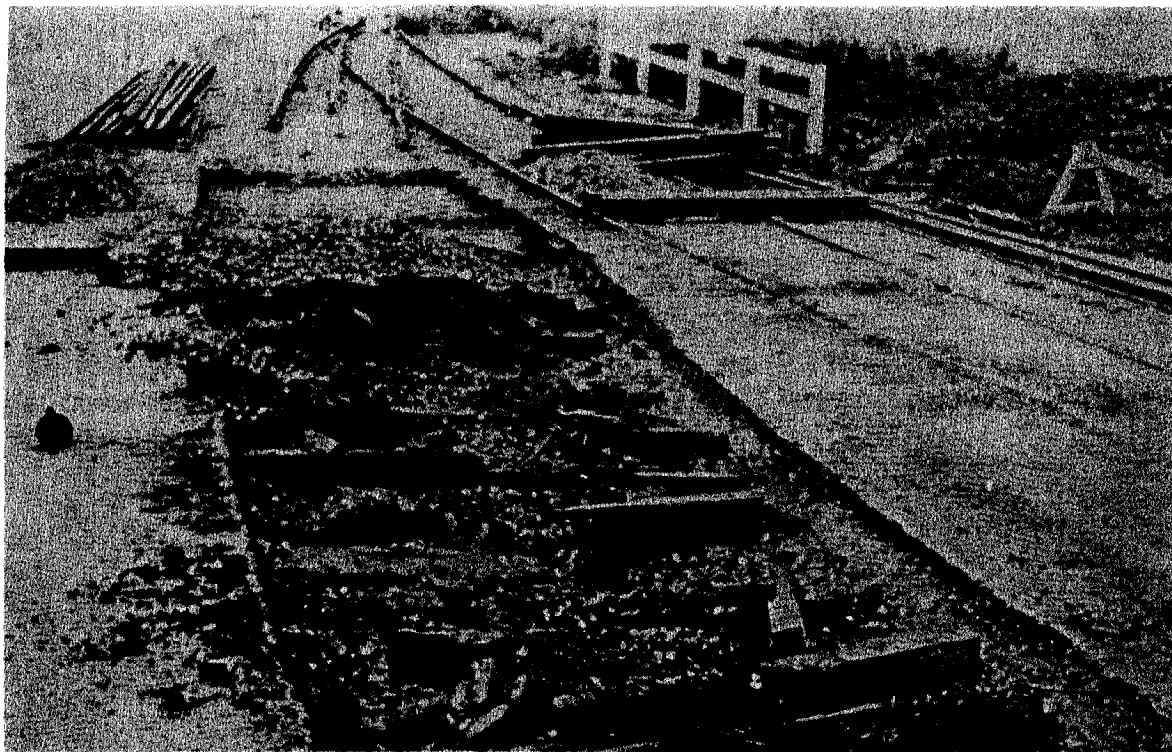


Figure 4-9. Ties decayed under paved area.

4-13. Crossing Surfaces and Materials.

4-13.1. General. Crossing surfaces must be as smooth as possible, and the materials selected for this purpose must be suitable for the type of traffic using the crossing. Although it may be desirable to match the material and texture of approach pavements, consideration must be given to a material and an installation that is economical to maintain and that will have a long service life. Materials such as Portland cement concrete or bituminous concrete are economical to install, but are costly to remove and replace. Wood plank and prefabricated materials may be a little more costly to install, but are removable and reusable and therefore are more economical to use in the long run. Further, because they are easily removed and replaced, they facilitate the inspection of the track. In plank-type crossings, the flangeways are often open down to the ties, which exposes the subgrade and ballast to the water, silt, and debris that flow to this opening. Regardless of the materials used, flangeways must be provided, 2-1/2 inches for tangent and nominally curved track. On curves over 8 degrees, the flangeways must be widened to 2-3/4 inches. Rubber and plastic crossing pads and rubber flangeway fillers are available for some types of crossings and should be installed, especially in areas where small-wheeled vehicles use the crossing.

4-13.2. Street and Highway Crossings. Street or highway crossings should be at least 4 feet wider through the crossings than the width of the approach pavements (Figure 4-10). When the crossing has to be repaired or replaced and the crossing is the same width as the approach pavements, the crossing width should be extended 2 feet on each side. The additional width is necessary to reduce the hazards of vehicles running off the sides of the crossing (Figure 4-10). The most frequently used crossing materials are listed below:

4-13.2.1. Bituminous Concrete. Where traffic is light, the entire crossing may be constructed by bituminous concrete. In very light traffic areas, the flangeways may be formed by running the locomotive wheels through the hot mix after it has been placed and rolled (Figure 4-11). Some finishing may be required to smooth the material that has been shoved out of the flangeway. However, at crossings with a high volume of traffic or heavy truck traffic, a flangeway guard is needed to protect the edges of the asphalt section between the rails. The guard may be constructed of wood (Figure 4-12). Metal flangeway guards may be fabricated from used rail (Figure 4-13) or purchased from commercial sources (Figure 4-14).

4-13.2.2. Portland Cement Concrete. Constructing a crossing with cast-in-place concrete requires closing

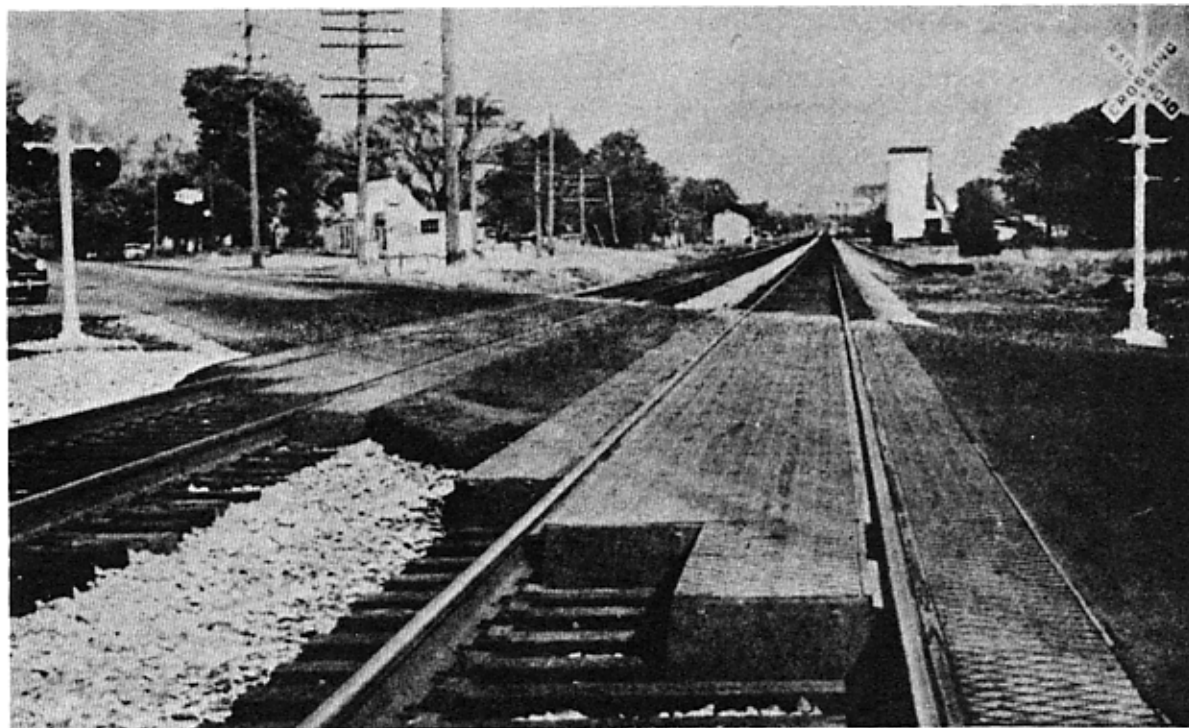


Figure 4-10. Double track crossing.

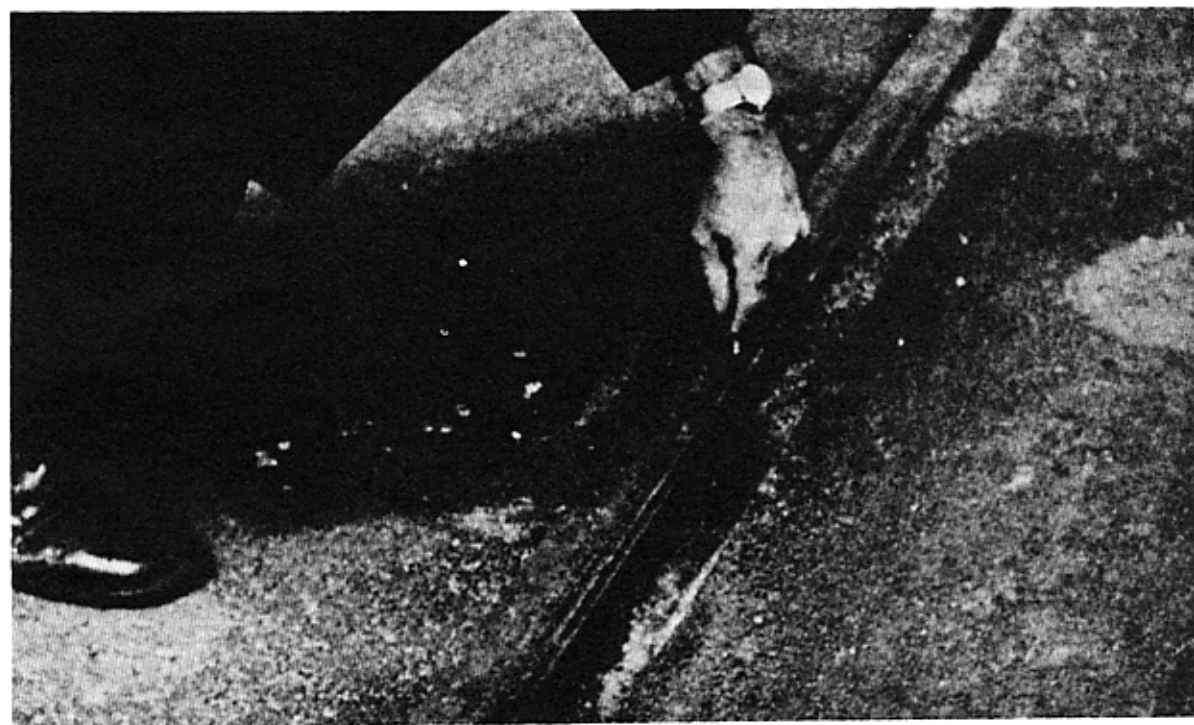
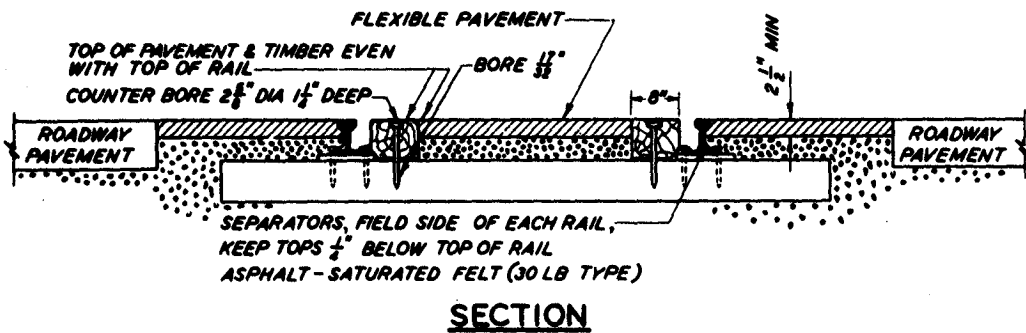
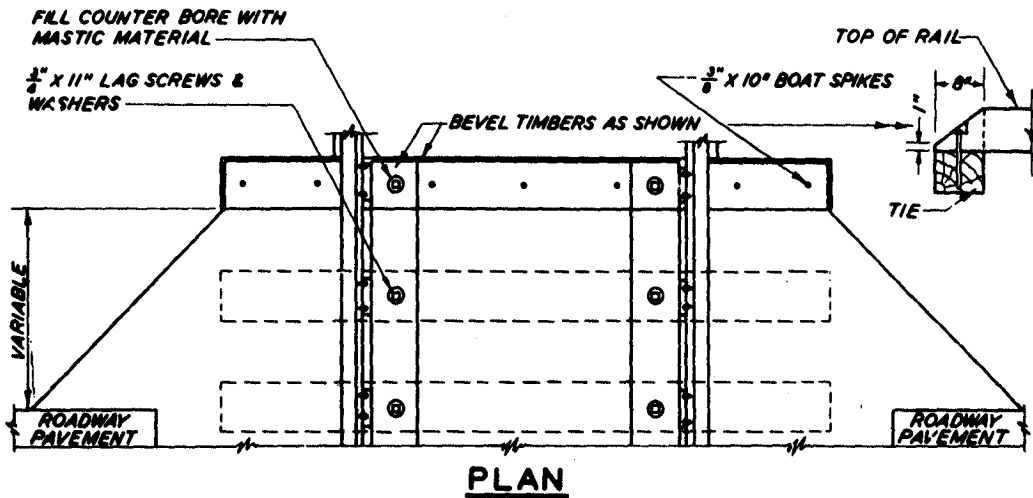


Figure 4-11. Bituminous concrete crossing flangeway made with engine wheels



NOTE: ALL TIES THRU THE CROSSING SHALL BE SAWED FORM A, SIZE 4, AND SPACING SHALL NOT EXCEED 20 INCHES.

Figure 4-12. Bituminous crossing with wood flangeway guard.



Figure 4-13. Used rail flangeway guard.

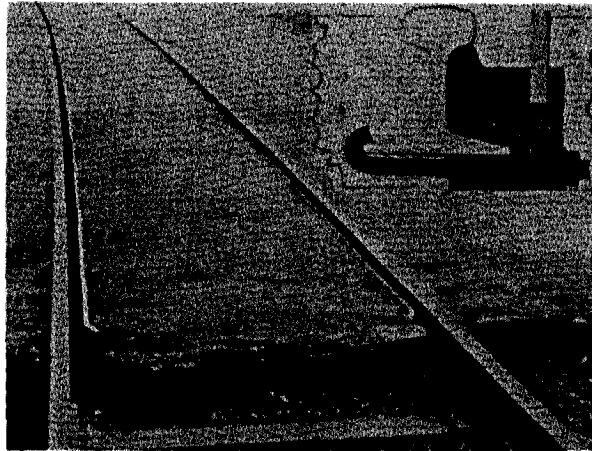


Figure 4-14. Metal flangeway guard.

the crossing or limiting vehicular traffic to one lane during construction and concrete curing. This type of crossing, however, provides a smooth riding and durable surface (Figure 4-15). A poured concrete crossing is costly to remove and replace.

4-13.2.3. Precast Concrete Planks. This type of material provides a long-lasting surface for all volumes of traffic. Several types of Portland cement concrete planks are available on the market for this purpose. Special care must be taken to insure even support throughout the length of each plank. Figure 4-16 gives plan and section views for a typical installation; Figure 4-17 shows a typical installation. Some types of precast concrete crossings are available with rubber fillers for the flangeway (Figure 4-18).

4-13.2.4. Wood Plank Crossings. This type of crossing has been successfully used for many years. Treated timber will last for a long time, but may require retightening of lag screws from time to time as they will become loose as the timbers flex under traffic. A well-maintained wood plank crossing is shown in Figure 4-19.

4-13.2.5. Prefabricated Rubber Planks. Prefabricated rubber planks provide a smooth riding, durable, and maintenance-free crossing. A typical installation is shown in Figure 4-20. This type of crossing, as well as other prefabricated types, is salvageable and can be reused..

4-13.2.6. Modular Plastic Crossings. Modular plastic crossings are durable, smooth riding, and practi-

cally maintenance free. The sections are molded and if a section is damaged, it can be replaced without disturbing any other sections (Figure 4-21). Used rail crossings are slippery when wet and do not afford a smooth ride to small-wheeled vehicles.

4-13.2.7. Used Rail. Crossings have, on occasion, been fabricated from rail that has been worn beyond further use in the track system (Figure 4-22). These rails, which should be the same weight as the running rails, are laid side by side, head up, between and parallel to the running rails with adequate flangeway. Used rail crossings are slippery when wet and do not afford a smooth ride to small-wheeled vehicles.

4-13.2.8. Two-Component Epoxy and Rubber. A poured in place two-component epoxy combined with rubber is available which seals the ballast from intrusion of water. This type crossing is expensive.

4-14. Track in Paved Areas.

The type of vehicular traffic, in particular the size of wheel and type of tire, determines the type of material and construction used adjacent to and between rails in paved industrial areas. Normally, cast-in-place Portland cement concrete or asphaltic concrete pavements are used with flangeway guards appropriate for the vehicular traffic (Figure 4-23). Where small-wheeled, solid-tired vehicles are used, a rubber flangeway filler is recommended. Flangeways may also be formed by the use of girder rail (A in Figure 4-23) through the crossing or pavement, or by placing used rail on its side with the head against the web of the running rails (B in Figure 4-23).

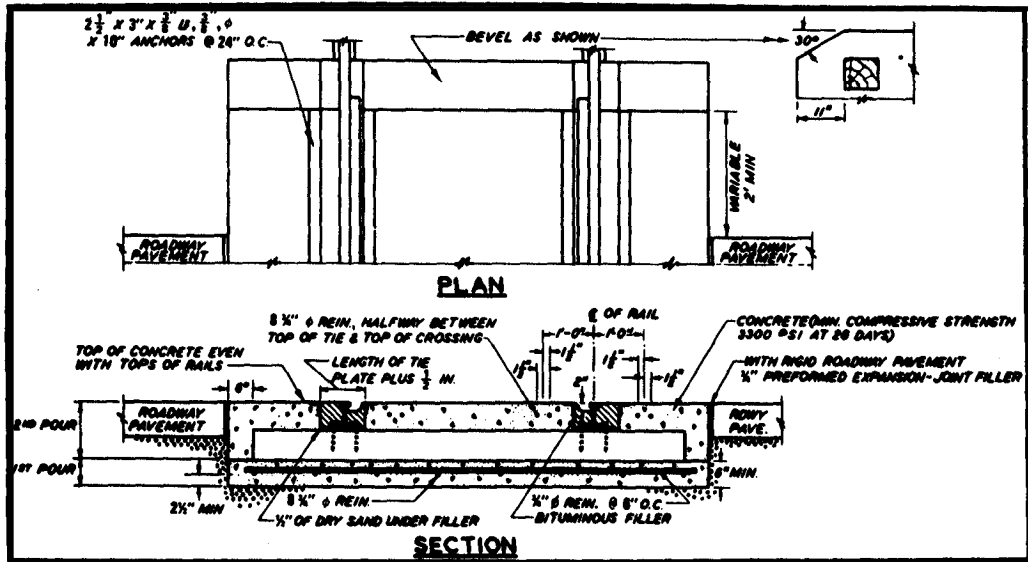


Figure 4-15. Cast-in-place concrete crossing.

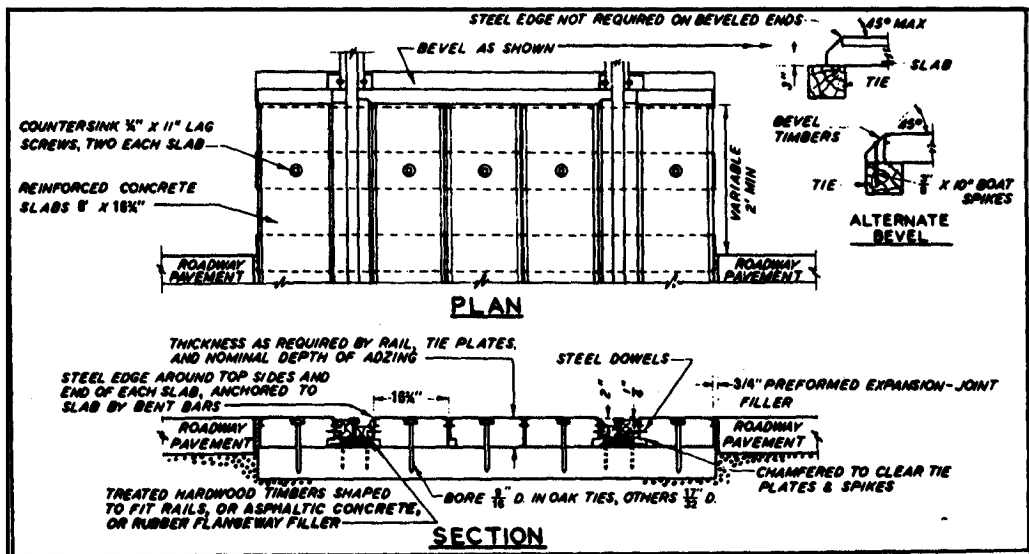


Figure 4-16. Precast concrete slab crossing.

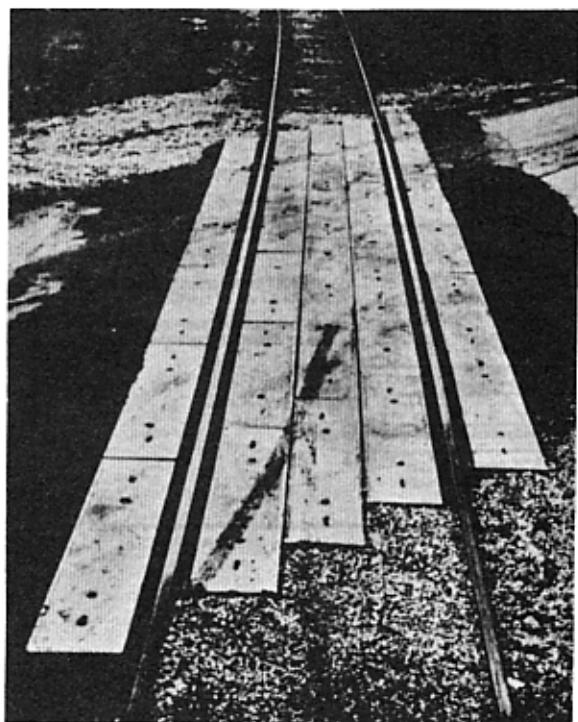


Figure 4-17. Precast concrete plank crossing.

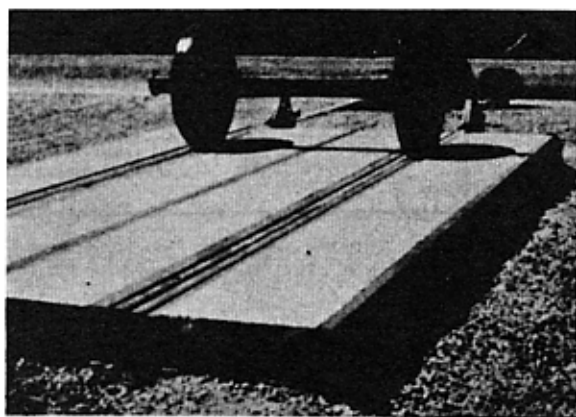


Figure 4-18. Precast concrete plank with rubber flangeway filler.

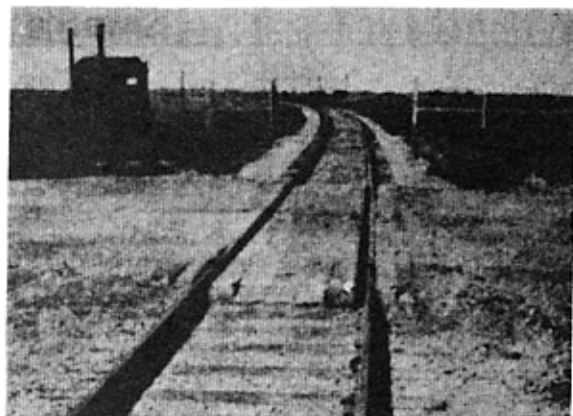


Figure 4-19. Timber crossing.

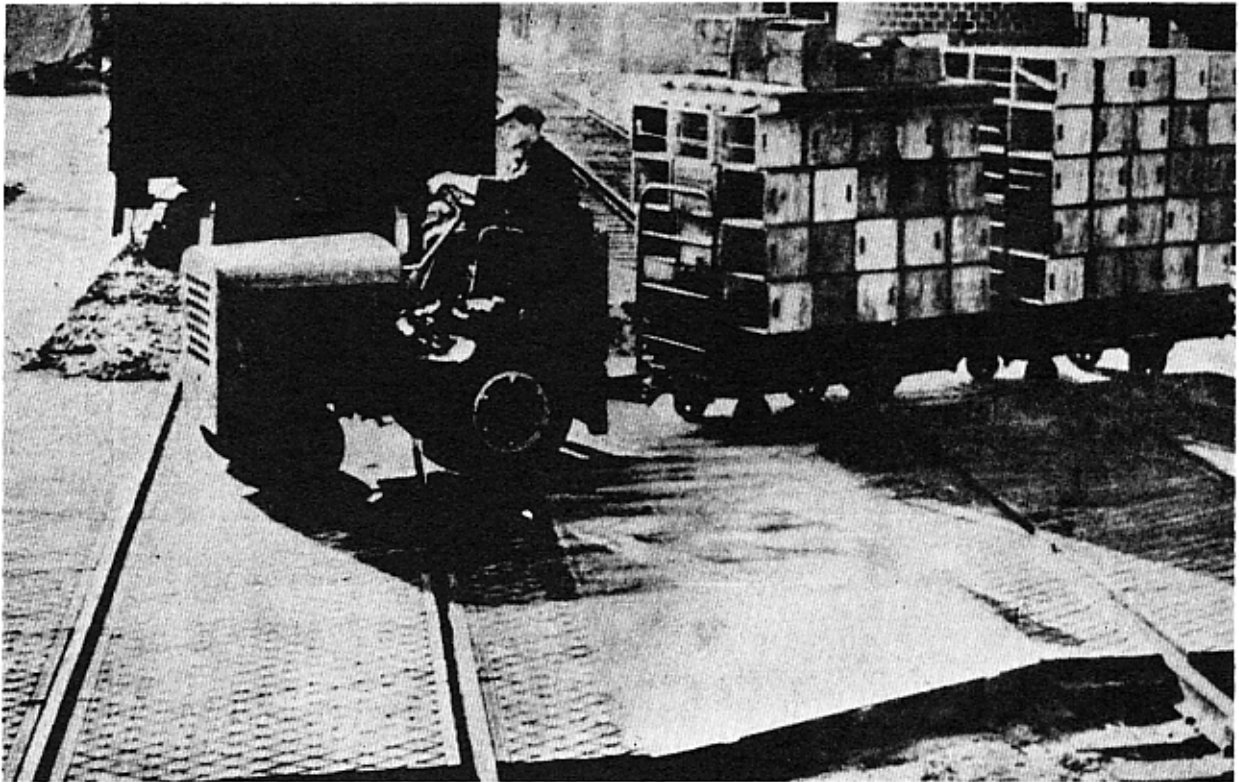


Figure 4-20. Rubber plank crossing.

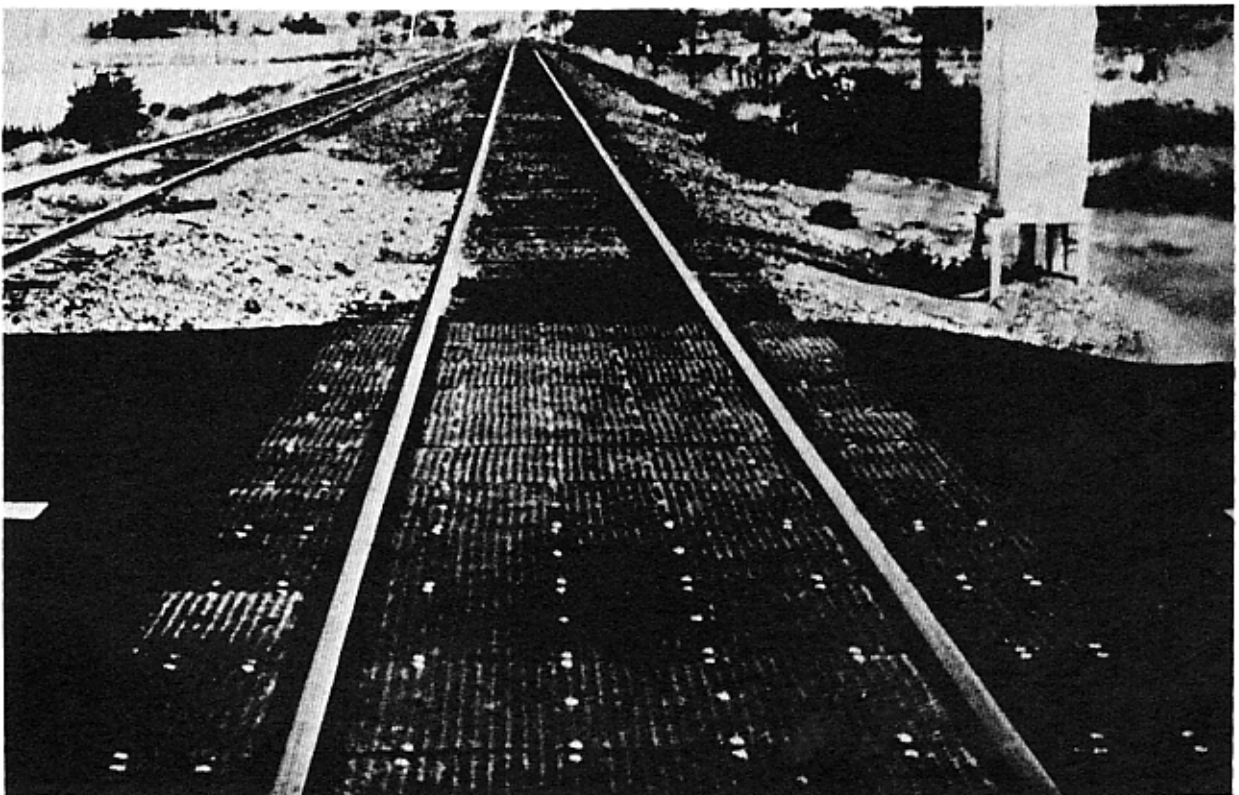


Figure 4-21. Modular plastic crossing.

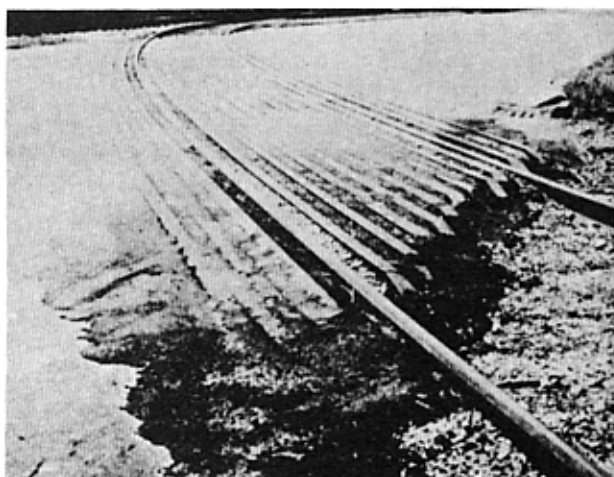


Figure 4-22. Used rail with asphalt filler.

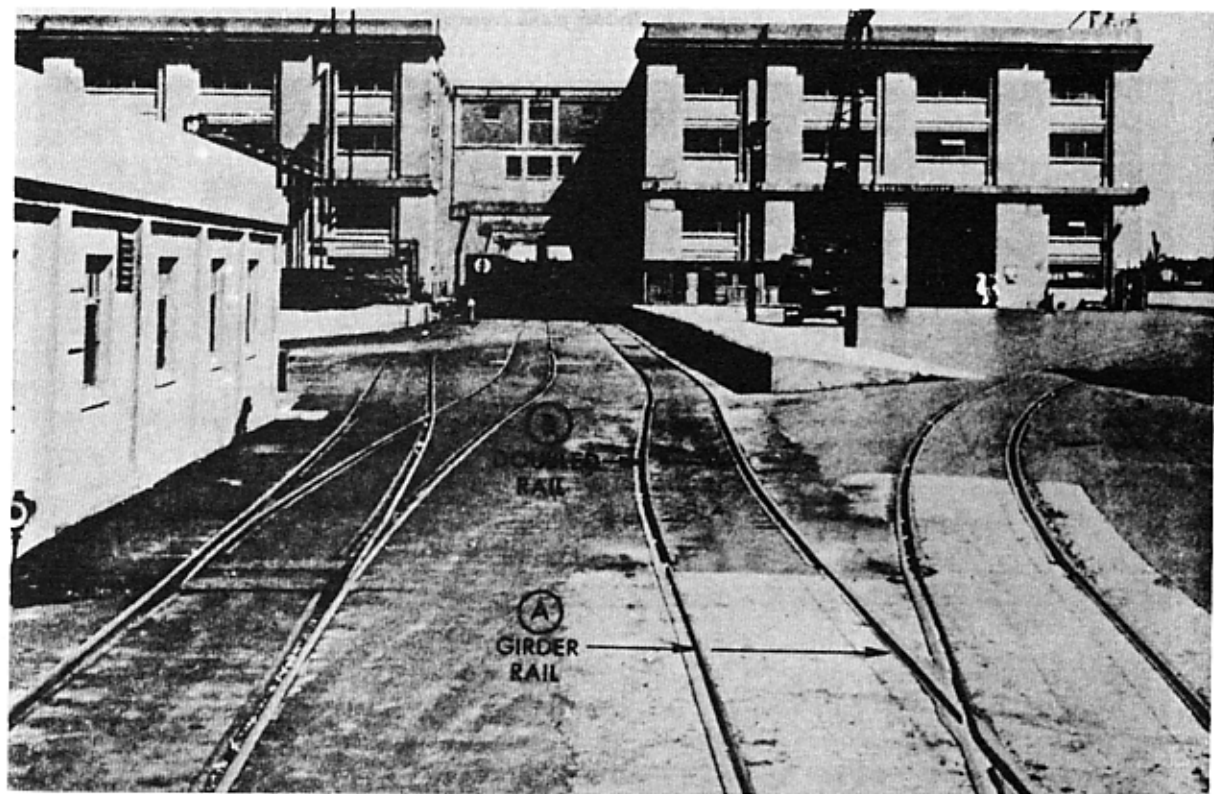


Figure 4-23. Trackage in paved area.

4-15. Signs and Signals.

Crossing sign and signal maintenance must be given a high priority to assure legibility and visibility.

4-15.1. Highway Crossing Signs and Signals. Standard highway-railway grade crossing signs are shown in Figure 4-24, a crossing signal in Figure 4-25, and location of signs and signals in Figure 4-26. For details of appropriate types of crossings and signals, see DOT Manual on Uniform Traffic Control Devices, Bulletin No. 6 of the Association of American Railroads (Railroad-Highway Grade Crossing Protection), and Chapter 9 of AREA Manual.

4.15.2. Maintenance of Signal Circuits. Electric and/or electromechanical signal inspection and maintenance should conform to AREA requirements and to manufacturer's recommendations. Circuit continuity checks, battery water level observations, trickle charger operating tests, relay point checks, light bulb

tests, and related checks and inspections must be made periodically as specified or required by the installation's maintenance program or the serving railroad. Indicated defects must be corrected promptly.

4-15.3. Signal Cables. Signal cables are buried around main track switches and signal locations. Cables are buried at toe of ballast between instrument housing, switches and signals in the track circuit system territory, at interlocking plants, and at switches equipped with electric locks, as well as automatic block signal location. Maintenance employees working on roadbed at these locations should be informed by signal forces as to exact locations of these cables. Machine operators must exercise care to avoid damage to underground cables at these locations. In case of doubt as to location of cables, do not work digging machines within interlocking home signal limits.

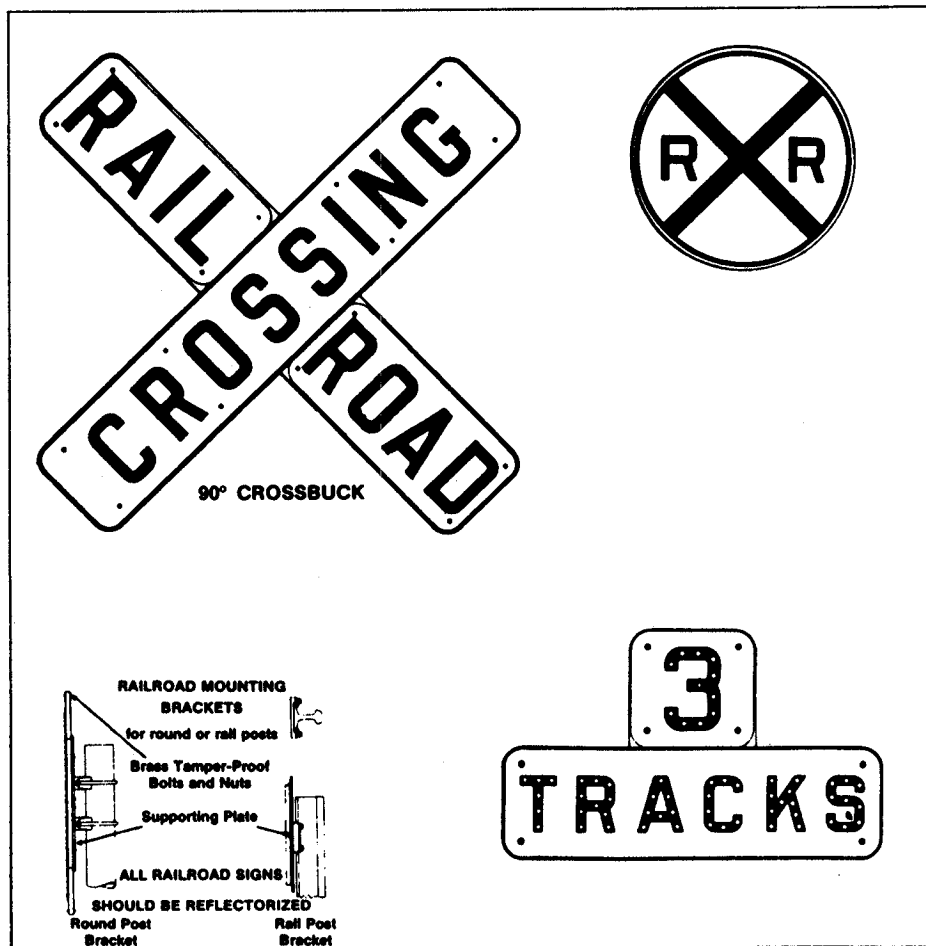


Figure 4-24. Typical grade crossing signs.

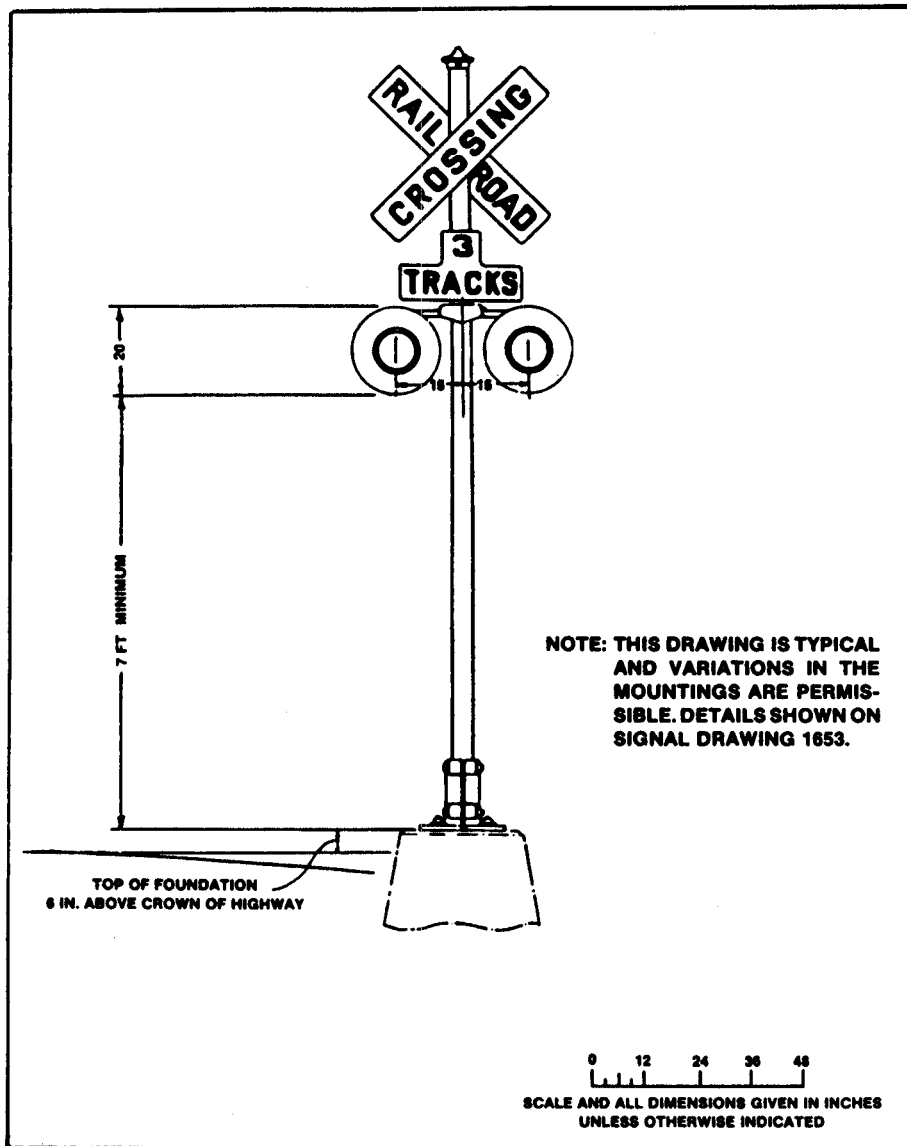


Figure 4-25. Highway crossing signal, flashing-light type with red signal sign.

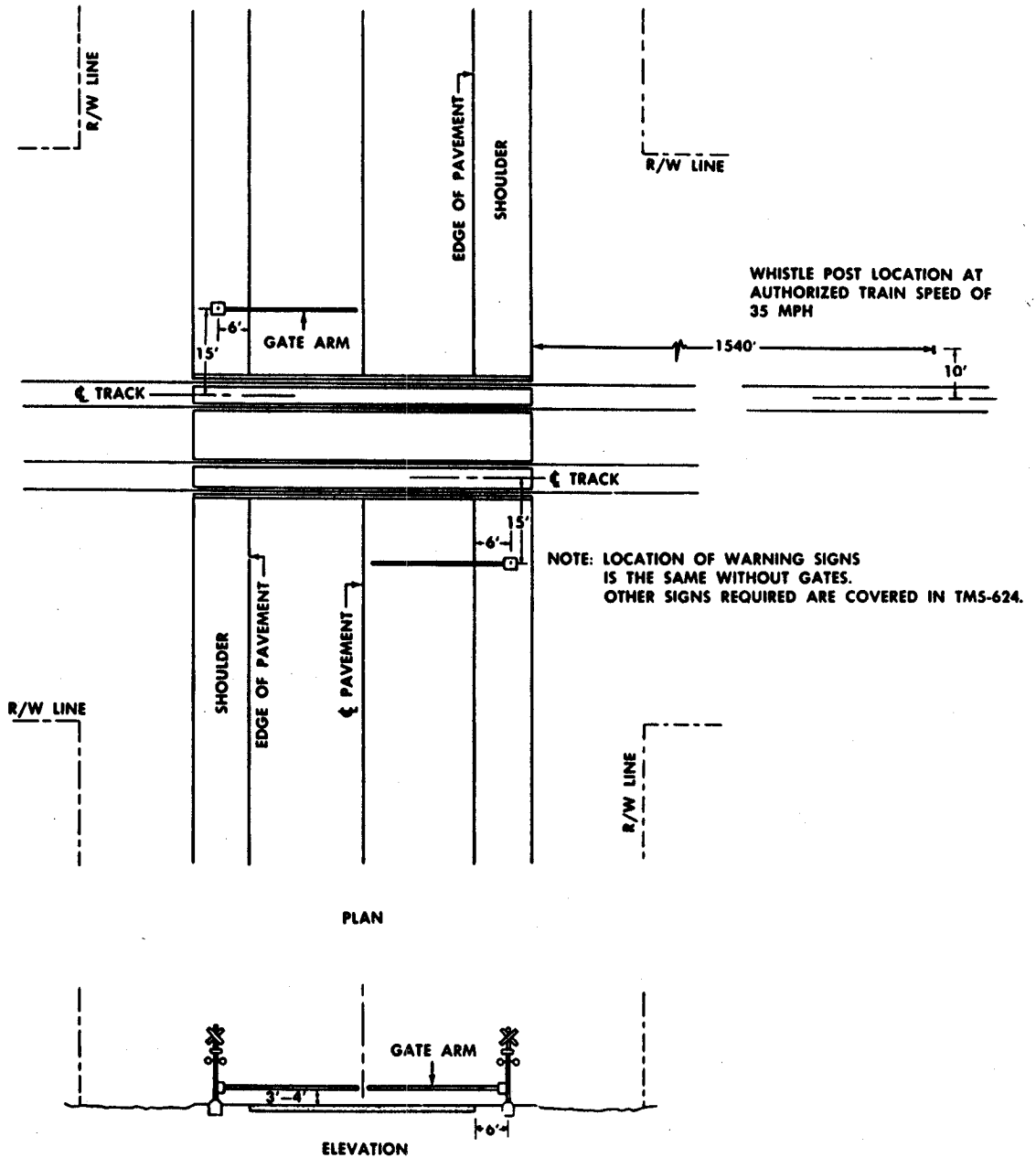


Figure 4-26. Location of warning signs and signals.

Section 3. MAINTENANCE OF ROADBED

4-16. General.

Good drainage is the most important single factor in roadbed maintenance. To provide maximum support for the track structure, subgrades should be kept as dry and stable as possible. Poor drainage not only affects the roadbed and the underlying earth structure (Figure 4-27) but also the side cuts and other track side areas. Where drainage deficiencies occur that cannot be corrected by normal maintenance practices, engineering assistance will be requested. Open ditches and pipe drains shall be maintained to function at maximum capacity. Weed control and efficient methods of ice control and snow removal are important factors in conjunction with water runoff. Inadequacies in the original drainage system shall be corrected as they become evident.

4-17. Inspection and Repair.

Alert, methodical, and timely inspection, with prompt correction of large and small defects, is necessary for the economical maintenance of drainage systems. The object is to preserve the original track and roadbed section by preventing obstructions that tend to divert

or impede the flow in the drainage system. Emergency repairs to drainage systems must be made when conditions require such action, but a general program of repairing and cleaning should be conducted annually, preferably in the spring or after periods of unusual storms or rainy weather.

4-18. Subsurface Drainage.

Water falling on ballast soon soaks through to the subgrade. Impervious subgrade not properly graded so that the water will drain off to the side ditches will cause pools to form, which soften the subgrade, resulting in low spots in the summer and possible heaving in the winter. Poorly drained subgrades are reflected in poor track surface. Resurfacing or raising track instead of providing proper subdrainage is only a temporary measure. Slopes for drainage may vary from 1 inch in 2 feet to 1 inch in 5 feet. The only remedy to eliminate wet spots is to reshape the subgrade so that water will flow toward the ditches. Also, stabilization can be obtained by cement-subsurface grouting (Figure 4-28). If the trouble is localized in a very small area, subdrains may be used to drain off the excess water.

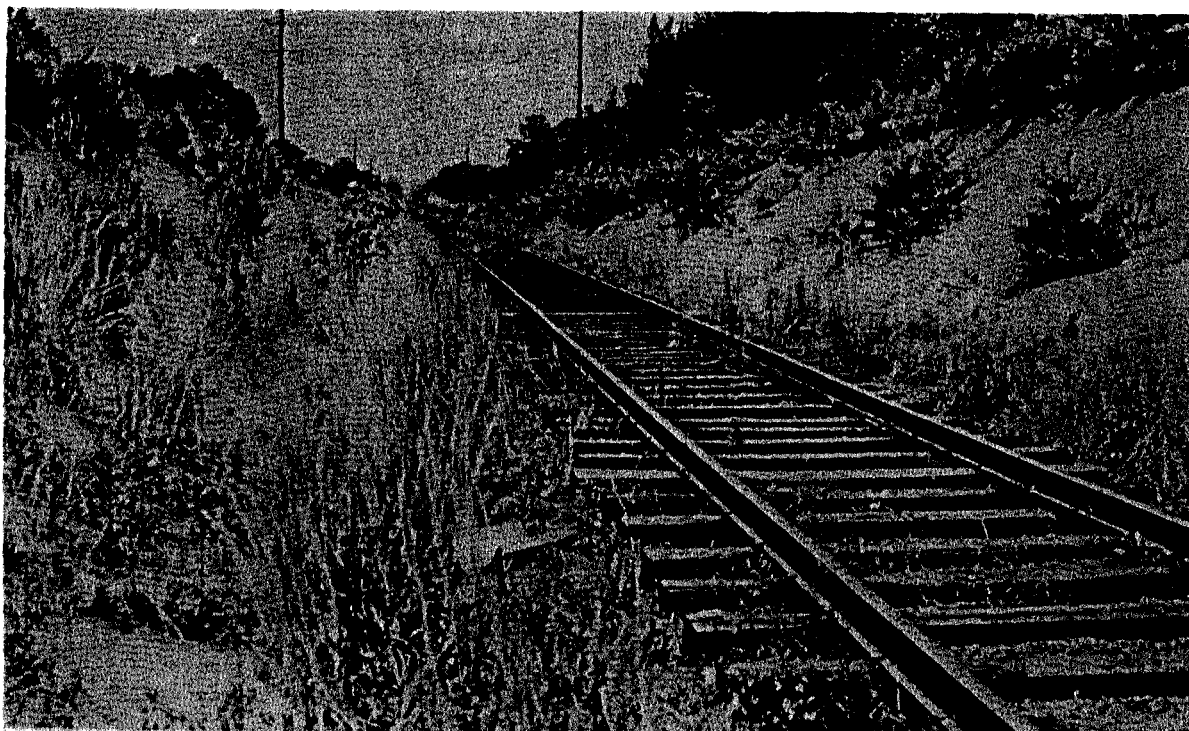


Figure 4-27. Ditches fouled by silt and vegetation.



Figure 4-28. Cement grouting soft roadbed.

4-19. Surface Drainage.

All surfaces must be sloped toward the drainage systems, and slopes maintained to minimize erosion during runoff. Drainage ditches and structures shall be kept in condition to dispose of runoff quickly. Obstructions that cause water to remain in pools shall be removed. Erosion of ditch sides and bottoms can be controlled by lining them with native grasses or by check dams, riprap, or pavement.

4-19.1. Ditch Maintenance. Where ditch maintenance is a constant problem because of faulty design or construction, permanent corrective measures may be required. For example, if the gradient is unsuitable, the ditch may scour (too steep) or may accumulate silt (too flat). Unchecked growth of vegetation (Figure 4-27) obstructs water flow and raises the water level in the ditch. This water can penetrate and soften the roadbed or restrict the drainage of the roadbed. Some soil wears away readily, and the slopes are eroded by rainfall and undermined by the flow of water in the ditch unless the gradient is correct and the streambed clear. Erosion of the ditch side slopes increases the silting in the ditch (Figure 4-29). Therefore, the side slopes must be stabilized or flattened to reduce erosion. Maintenance and repair measures must be determined to fit existing conditions.

4-19.2. Causes of Drainage Failure. Causes of failure have been mentioned generally in the preceding paragraphs. The following describe these causes in more detail.

4-19.2.1. Erosion. Erosion occurs when the velocity of the water or wind on the slope of an embankment or ditch causes the water to dislodge the soil from these areas and carry it away. The degree to which the velocity affects the ditch and side slopes depends upon the stability of the soil or the protection it has been given by additional stabilization. Loose, sandy, or silty soils are easily eroded at almost any velocity. Such soils must be stabilized by vegetative cover or often by riprap or concrete blankets. Riprap or concrete blankets have to extend sufficiently below the ditch bottom to prevent undermining. The most satisfactory solution to erosion control is to flatten the slope to reduce the velocity of the water to the rate that will keep erosion to a minimum and yet prevent unacceptable silting. This may require reconstruction, such as installing check dams or flattening the slope, that is beyond the scope of maintenance.

4-19.2.2. Lack of Drainage. When drainage is inadequate, unwanted water remains in the roadbed long enough to soften the subgrade. Dirty ballast can reduce the drainage of water as effectively as a stopped drain. Improperly shaped subgrade or pock-

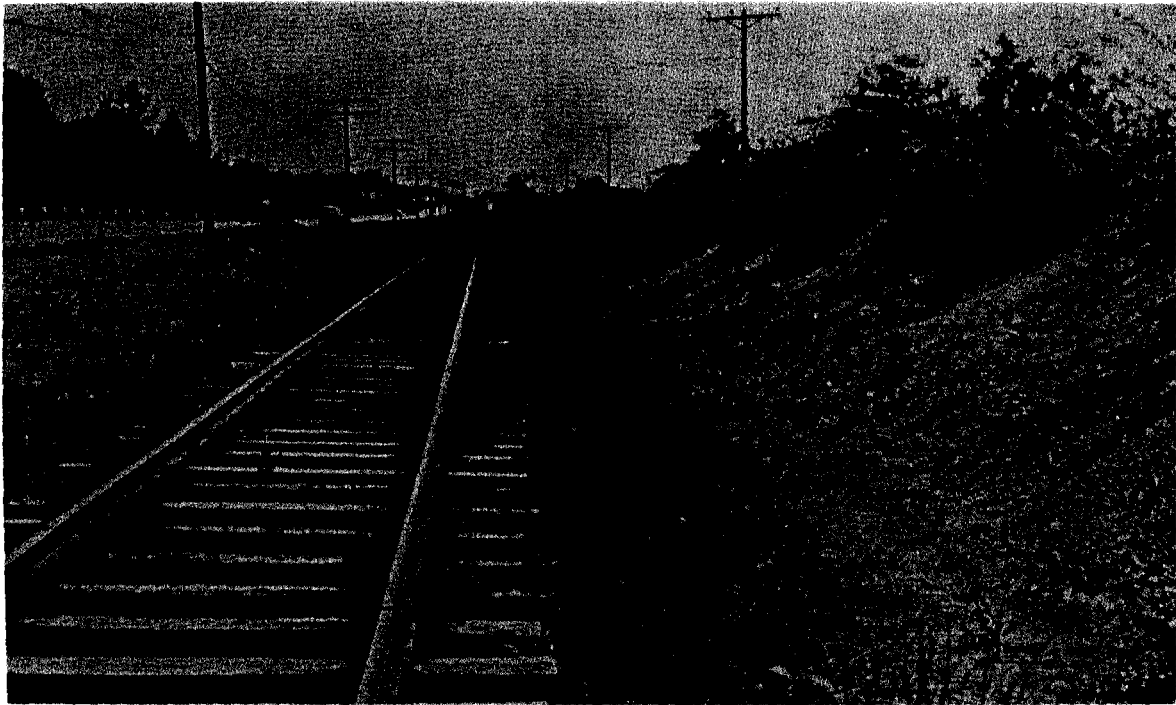


Figure 4-29. Erosion of side slopes.

ets that have developed in the subgrade can impound water to the detriment of the track system. Sub-drains may become clogged, or the buildup of silt in the adjacent ditches will reduce the flow of water from beneath the track structure. Besides weakening the subgrade, trapped water during the winter can cause heaving. If this water freezes, it further retards the drainage which increases the problem (Figure 4-30).

4-19.3. Corrective Measures. Where it can be used effectively, off-track power equipment gives more economical results for the cleaning of intercepting and drainage ditches than other methods. Handwork may be necessary where equipment is not available or where conditions prevent access of mechanical equipment. Ditching of ordinary material in side ditches in cuts may be subdivided into two principal classes, shallow cuts and deep cuts.

4-19.3.1. Shallow Cuts. Ditching in shallow cuts can be done with road graders that are equipped with blades for shaping ditches and slopes, by draglines, or under some conditions, by tractor-drawn scrapers. Such ditching shall not be done by hand where the magnitude of the work justifies the use of heavy equipment.

4-19.3.2. Deep Cuts. Where the volume of material to be removed is comparatively small, the work usually can be performed with graders. Handwork

will not be resorted to unless a careful analysis shows the use of power equipment is not possible.

4-19.3.3. Use of Road Machinery. Where the volume of material to be removed is large, the cuts are long, or the points of disposal are remote, the use of power ditchers or other heavy excavating machinery is justified whenever it is available. For example, if the terrain is such that draglines can work along the top of the cut, comparatively deep cuts can be cleaned quickly, at less expense than by other methods, and with no interruption of railroad transportation. Power scrapers or trucks and power shovels may be the most practical machinery to use.

4-19.3.4. Use of Car-Mounted Machinery. Where the depth of the cut, the desire to use the excavated material, or other conditions justify, power-operated ditchers or draglines mounted on cars are effective. A work train is necessary, and the usual arrangement is to place the ditcher or dragline between two air-dump cars. Before using work trains and on-track equipment, a very careful analysis shall be made of the situation to see whether the cleaning can be done satisfactorily by methods not affecting train movements. Where the personnel and equipment capability of the organization are not adequate to perform extensive maintenance, repair, or rehabilitation of railroad trackage, consideration shall be given to the use of contractual services.

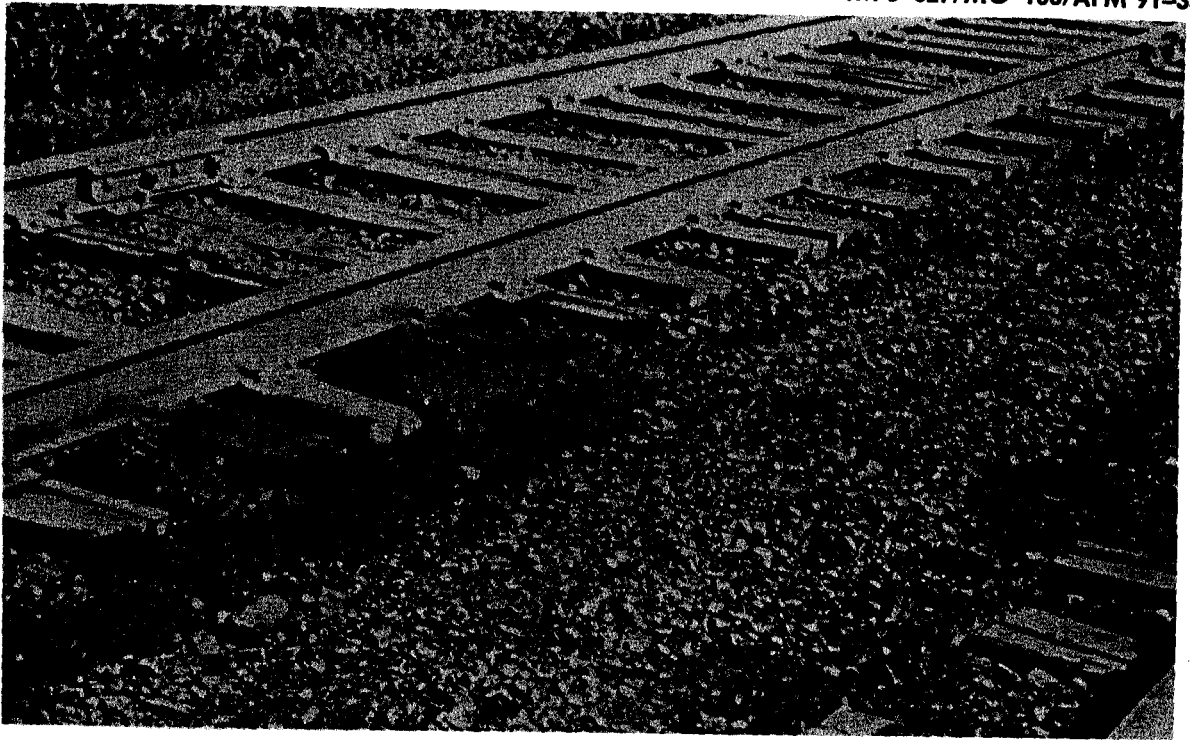


Figure 4-30. Inadequately drained roadbed.

4-19.3.5. Disposing of Surplus Earth Material. In all cases, waste material should be disposed of so it will not wash back into the cut. Material removed from side ditches shall never be cast on the adjacent slope. When waste dirt is disposed of along embankments, it should be deposited at an elevation below the bottom of the ballast.

4-20. Storm Pipe Drains.

A regular program of maintenance of pipe drains should be conducted. As-built record plans must be kept current regarding changes in the system. Limits of covered drain shall be marked with adequate signs to facilitate inspection and maintenance.

4-20.1. Routine Maintenance.

4-20.1.1. Outlet Ditches. Ditches leading from outlet pipes shall be kept clean, with adequate width, depth, and grade to insure proper drainage. Side banks should be maintained with sufficient slope that the material involved will not slide. Ditches should be maintained free of vegetation, debris, and other obstructions. Irregularities in alignment and grade tend to cause silting and scouring and should be avoided.

4-20.1.2. Outlet Pipes. Screens on outlet pipes shall be kept in place to prevent small animals from entering pipes. When silting occurs at the outlet, screens shall be removed and the opening cleaned.

Special care should be given outlets to make certain that stoppage does not occur.

4-20.1.2.1. Overflow. Occasionally, drainage pipes discharging near bridges and culverts are subject to overflow or backwater during high water. Inspection should be made as soon as water recedes, and if necessary the pipe drainage system flushed.

4-20.1.2.2. Inspection. Frequent inspection of the mains shall be made through the risers. Any tendency to silt must be carefully watched, and, when it occurs to a marked degree, the entire system of mains should be flushed with water from a water car or other convenient supply. This is especially necessary for systems involving near level grades.

4-20.1.2.3. Vegetation. Trees, bushes, or vegetation with deep roots shall not be allowed to grow near any line of subsurface drainpipe. The roots, seeking water, may fill the pipes and cause stoppage in the system.

4-20.2. Correcting Failures. Rapid silting of main drains indicates an obstruction, a level spot, or reverse grade, which must be located and corrected. In excavating for obstructions, care shall be exercised to prevent fouling the drains. The excavation should be backfilled with permeable material similar to that specified in the original design. Any tendency toward further development of water pockets or soft spots and heaving must be studied, and test holes dug to

determine the direct cause of failure. If failure caused by a defect in the pipe drains occurs, immediate repairs shall be made. If heaving is caused by obstinate water pockets or soft spots that are not tapped with laterals, laterals should be installed.

4-21. Soft Spots and Water Pockets.

4-21.1. General. Soft spots and water pockets exist in localities where soil conditions are unfavorable to satisfactory maintenance, particularly in clay. They will be found in both fills and cuts, but more generally in clay cuts. In soft spots the ballast generally has settled into the roadbed, forming a trough or pockets under the track. This condition usually causes the subballast and roadbed to be pushed out laterally and oftentimes raised (see Figures 4-31 and 4-32), thus forming walls that prevent the water draining from the track. This condition invariably results in water pockets. The usual methods of surfacing and tamping track have no permanent effect in correcting soft spots and water pockets. Soft spots and water pockets shall be given prompt attention because they soon develop into a serious defect. The longer they exist, the more hazardous they become, and the greater the resulting maintenance expense or time and cost involved in providing a permanent remedy.

4-21.2. Corrective Measures. In minor areas of soft spots or water pockets, the maintenance crew may take corrective action by increasing drain fields. However, in addition to pipe drains, various new methods of stabilizing soft spots and water pockets have been developed, such as roadbed grouting, the driving of poles or ties, and the use of sandpiles. In severe cases the situation should be studied by the engineers to see which method will probably give the most economical and satisfactory results.

4-21.2.1. Pipe Drain Method. Test holes shall be made at intervals frequent enough to determine accurately the profile of the bottom of the water pockets. Lateral drains shall be spaced so as to tap all the pockets; 16 feet center to center will usually suffice. The main and laterals shall be placed in stable material, with the minimum depth of the main 24 inches, and of the lateral 12 inches below the bottom of the deepest pocket, unless the surface of solid rock or hard shale lies at a lesser depth; in this case, the minimum depth of the main can be reduced to 12 inches below the bottom of the deepest pocket. Quite often the "softest" cuts are of a clay material overlying rock or shale. Usually this harder underlying stratum is not on a uniform plane, but is irregular, and if it is uniform it will not conform with the grade of the main. To prevent dislocation of the drainpipe, it is well to place the pipe into the rock or shale to a depth at least equal to the diameter of the pipe.

4-21.2.2. Grouting.

4-21.2.2.1. Principle. As has been described previously, water pockets are caused by ballast being driven into the subgrade due to traffic passing over the rails. After the ballast has been driven into the subgrade (impervious soils), heaving occurs along the shoulder of the roadbed. This heaving material is an earth slurry created by the action of traffic vibrating the ballast against the grade, thus mixing earth and water and forcing it out at the toe of the ballast section. As a rule, free water is indicated below the area under vibration. The grouting method for curing this condition consists of pumping a concrete slurry into the void in the subgrade. The grout is pumped into place until the void is filled and its pressure has raised the roadbed back to the desired elevation. It is possible to determine that the void (water pocket) is

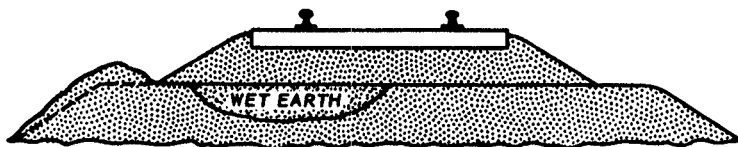


Figure 4-31. Effect of water pocket under one end of ties.



Figure 4-32. Effect of a water pocket under the middle of ties.

filled by observing leakage of the grout up through the surface or along the fill section. The grout consists of a very fine sand and enough cement to provide a partial set of the slurry (a rigid concrete base is not desirable). Immediately following the grouting, the track should be checked for elevation and lined out-of-face.

4-21.2.2.2. Machinery and Equipment. If grouting is necessary and grouting equipment is not available at the installation, the equipment used in pavement mudjacking and undersealing is suitable for railroad grouting.

4-21.2.2.3. Other Material. Under certain conditions, bituminous materials may also be used for subsurface sealing. The methods for placing are similar to those for cement grout slurry. *

4-22. Slides.

4.22.1. General. Slides usually occur in unconsolidated material, but may occur in open faces of rock formations. Gravity is a primary cause, supplemented by lubricating water; undermining (natural or artificial); clay-type material; certain types of geological structure; increase of load; and, in the case of rock slides specifically, by joint planes; fault planes; schistose structure; or strata dipping toward an open face. In the latter cases, slides are often accentuated by clay seams in partings of the rock. Where embankments are subjected to hydrostatic head for a length of time sufficient to saturate the embankment, slides may occur suddenly and without warning, particularly if the material is disturbed, as by spreading operations.

4-22.2. Corrective Measures. Each slide shall be considered an individual problem. The cause of the slide should be determined by thorough and expert examination, under the direction of an engineer, of the soils, drainage conditions, and geological conditions related to the slide. The prevalence of unstable material will be ascertained in order to arrive at a decision as to economic preference between the removal of sliding material and the application of suitable control methods. The removal or prevention of the cause of a slide is as important as the restoration of the roadway.

4-22.2.1. Piles or Retaining Walls. Piles or retaining walls for the prevention or correction of slides may be used based on engineering evaluation.

4-22.2.2. Diversion of Surface Water. Surface water must be intercepted and diverted by surface ditches.

4-22.2.3. Drains. Underground water must be drained away, or intercepted at its underground source, and diverted. Slides caused by the flow of underlying material often may be controlled by con-

structing subsurface drains containing perforated pipe and draining around the toe of the slide. When this unstable underlying material is deep, tunneling to intercept the flow may be necessary. When feasible, water cutoff is usually more economical and effective than trenching or tunneling. Subsurface drains with perforated pipe are sometimes necessary to remove underground water from the slide itself when it is impractical to remove all the sliding material in hillside or cut slides. This control method is usually coupled with removal of sliding material, slope modification, and water cutoff, or intercepting drainage.

4-22.2.4. Terracing. Terracing or benching the slope lightens the load and may lessen or prevent sliding. This may be done in addition to using other methods of control. The removal of the entire moving mass in hillside or cut slides may be more economical than control methods.

4-22.2.5. Compacted Berms. Firmly compacted berms, approximately one-third the height of the fill, will help stabilize the fill and may be used in connection with drainage control methods. Weighting of the toe of a slide is useless if movement exists throughout the mass. When used, the weight must rest upon or be carried down to solid material.

4-23. Frost Heave.

4-23.1. General. When water collects unevenly under the track and expands because of freezing, the track is lifted above the wet spots and produces what is known as "heaved track" (Figures 4-31 and 4-32). The extent of heaving caused by frost action depends on the character and condition of material in the ballast and subgrade, the amount of moisture retained, and the extent and duration of low temperatures.

4-23.2. Corrective Measures. Maintaining shimmed track is costly in maintenance time, and the repeated spiking of ties due to placing and adjusting shims and braces reduces the service life of the ties. However, such maintenance may be necessary until permanent corrective action can be taken. Careful study and considerable work and expenditure are warranted for protection against trackage heave caused by frost action.

4-23.2.1. Drainage. On existing tracks, proper drainage is the principal factor in eliminating and heaving of track.

4-23.2.2. Isolated Cases. Where heaving occurs in isolated places on fills, much may be accomplished by digging out the soft areas of the subgrade to a depth of 2 feet or more and carrying the excavation to the shoulder to afford proper drainage and so decrease the tendency to form water pockets. The excavation

should be backfilled with clean coarse gravel or similar material and an adequate depth of good ballast applied.

4-23.2.3. Underdrains. In wet cuts, the installation of perforated underdrains backfilled with porous material provides excellent results.

4-23.2.4. Subgrade. If the subgrade obstructs drainage of the ballast section, it will be graded off and replaced with permeable material to the depth necessary to correct the condition.

4-23.2.5. Shoulders. In some cases where the embankment is built of impervious material, grading the shoulder off the ends of the ties and to a depth of 3 or 4 feet and replacing it with pervious material may be justified. Before undertaking such a project, careful exploration must be made to assure that the wet spots will be drained. Where depressions exist in the roadbed, free drainage to the shoulders must be assured before this method will function.

4-23.2.6. Stabilization. Cement or soil slurry (Figure 4-28) or bituminous subsealing may be used to permanently stabilize roadbed areas subject to freezing where heaving is extensive and the expenditure is justified. Installation of membrane materials may be considered in special cases. Traffic loads, frequency of use, and dependence of the installation on its railroad facility must be considered, as well as availability of maintenance crewmen and equipment to do the work.

4-24. Drainage of Yard Tracks.

Railroad yards are usually located on fairly flat terrain and require special drainage treatment. Because large, open ditches in railroad yards are objectionable, pipe storm drains and subdrains are required unless natural soils are particularly suitable for self draining. Periodic inspections, rodding, and cleaning of installed drainage systems are necessary if they are to function satisfactorily. As conditions change at a given installation and additional facilities are added, or as clearing and building of adjacent areas increase the water shed of the area, it may be necessary to adjust subsurface and runoff facilities at yards.

4-25. Vegetation Control.

The elimination of vegetation from areas where it is not required for erosion control is essential to economical maintenance of tracks, as well as to the appearance of the roadway. Vegetation should be controlled or eliminated to at least the limits of the ballast section to minimize the danger of fires. Proper visibility of traffic signals must be maintained. Dirty ballast permits the growth of weeds that interfere with drainage and shorten the life of ties. The remedy is to clean the ballast. Use approved herbicides to eliminate vegetation from ballast and other areas of

the roadway. Consult a specialist in this field for the best material and method to use. Weeds along the roadway can be controlled by mowing, burning, or by using herbicides. **NOTE:** It is mandatory that personnel handling herbicides be certified.

4-26. Snow and Ice Control.

Snowfall in amounts sufficient to obstruct railroad traffic or hinder operations can be expected at northern installations. Ice and packed snow can be a problem at crossings and in industrial areas where the tracks are in the pavement.

4-26.1. Snow Plan. A snow plan should be prepared in advance of the snow season in conjunction with the snow plan for installation roads. The plan must contain data on materials, manpower, and procedures to be used under varying storm conditions.

4-26.2. Snow Fences. Snow fences keep snow from drifting onto the roadbed in localities where heavy snowstorms are frequent. Effective placement of snow fences can be assured by keeping records of locations where drifts have occurred during the winter season.

4-26.3. Snow and Ice Removal. Snow and ice will be removed promptly from switches, frogs, guardrails, and flangeways at highway crossings. Also, snow and ice will be removed promptly from loading platforms, track scales, turntables or transfer tables, and from any other places where personnel or property may be endangered.

4-26.4. Chemical Control. Snow and ice control chemicals, sodium chloride (salt), calcium chloride, and urea are effective in melting ice and packed snow. The lowest temperatures at which these chemicals are effective under field conditions are: urea, +25°F (-4°C); and calcium chloride, -20°F (-29°C).

4-26.5. Snow-Melting Heaters. Snow-burning cans may be used to advantage. At switches where serious snow and ice conditions are expected over long periods, snow-melting pots or switch heaters may be used. Electrical switch heaters are not recommended because of the high operating cost.

4-27. Roadway Cleanup.

During surfacing, lining, gaging operations, and the like, all deficiencies noted should be corrected each working day. The shoulder line must be clearly defined, berms cleaned or raked, and drainage ditches cleaned. All scrap metal shall be collected and taken to a designated storage place. Old ties unfit for further track use or for cribbing shall be disposed of by burial in landfill or by another method of disposal that does not conflict with pollution laws. All rubbish and waste must be cleared from the work, and the entire right-of-way left in a safe and workmanlike condition.

CHAPTER 5. STRUCTURES

Section 1. TYPES OF STRUCTURES

5-1. General.

This chapter provides guidance for maintaining structures that are a part of the trackage system and some that may affect railroad operations. Bridges, trestles, and box culverts are used for water crossings, pedestrian walkways, roadways, other tracks, and drainage systems. Tunnels and cuts are used to penetrate hills or pass under bridges and other structures. The ensuing paragraphs of this chapter describe effective, preventive maintenance and/or the corrective measures appropriate for the several types of deficiencies usually encountered.

5-2. Supporting Substructures.

Bridges, trestles, and buildings shall be inspected using designated procedures and checkpoints. Supporting structures for elevated cranes should be inspected following each crane load test when cranes

are load tested to 125 percent or more of the manufacturer's rated capacity. Inspection reports shall be reviewed and random observations made of rail supports, connections, braces, and beam to column joints for indications of movement, deterioration, or stress. Broken and defective components shall be scheduled for repair or replacement. For wood, steel or concrete columns, beams, braces, girders, and other structural members, indications of settlement, misalignment, or deflection shall be recorded. Deflection, movement, or settlement under routine in-service loading exceeding established limits shall be investigated, analyzed, the degree of damage documented, and the classification of hazard determined. Structural conditions leading to a critical or catastrophic category of a section of trackage shall be based on a review of the structural analysis and on a condition survey conducted by competent engineers in sufficient detail to establish the safety of the structure.

Section 2. MAINTENANCE OF STRUCTURES

5-3. Bridges and Culverts.

Railroad bridges may be constructed of steel, concrete, masonry, or wood. Steel bridges may be through-truss, through-panel girders, deck truss, or deck panel girder types. These bridges may be open deck or ballasted deck. As far as the bridge structure is concerned, maintenance procedures are generally the same for all types. However, track maintenance will differ between the open deck and ballasted deck bridges.

5-3.1. Open Deck Trackage. On open deck trackage, bolts that secure the ties to the stringers may work loose as the bearing areas of the ties on the stringers become worn, as the ties swell and shrink with moisture changes, or as rot or insect damage develops. Loose bolts on a number of adjacent ties can result in excessive gage and alignment deficiencies. Figure 5-1 shows an open deck pile trestle specially designed for dumping hopper bottom dump cars.

5-3.2. Ballasted Deck Trackage. Ballasted deck trackage is maintained in the same manner as on a regular roadbed. The only extra maintenance required in the trackage is to keep the drainholes unplugged and free draining (Figure 5-2).

5-4. Guardrails.

On structures and approaches, guardrails are installed to guide equipment and prevent it from leaving the rail. Maintaining guardrails in first class condition requires that loose spikes be replaced or redriven, broken tie plates be replaced, and joint bars and track bolts be tightened. These maintenance operations should be performed at least quarterly on heavily used trackage.

5-5. Expansion and Bearing Assemblies.

All expansion joints must be maintained clean and free of incompressible material, which, when struc-

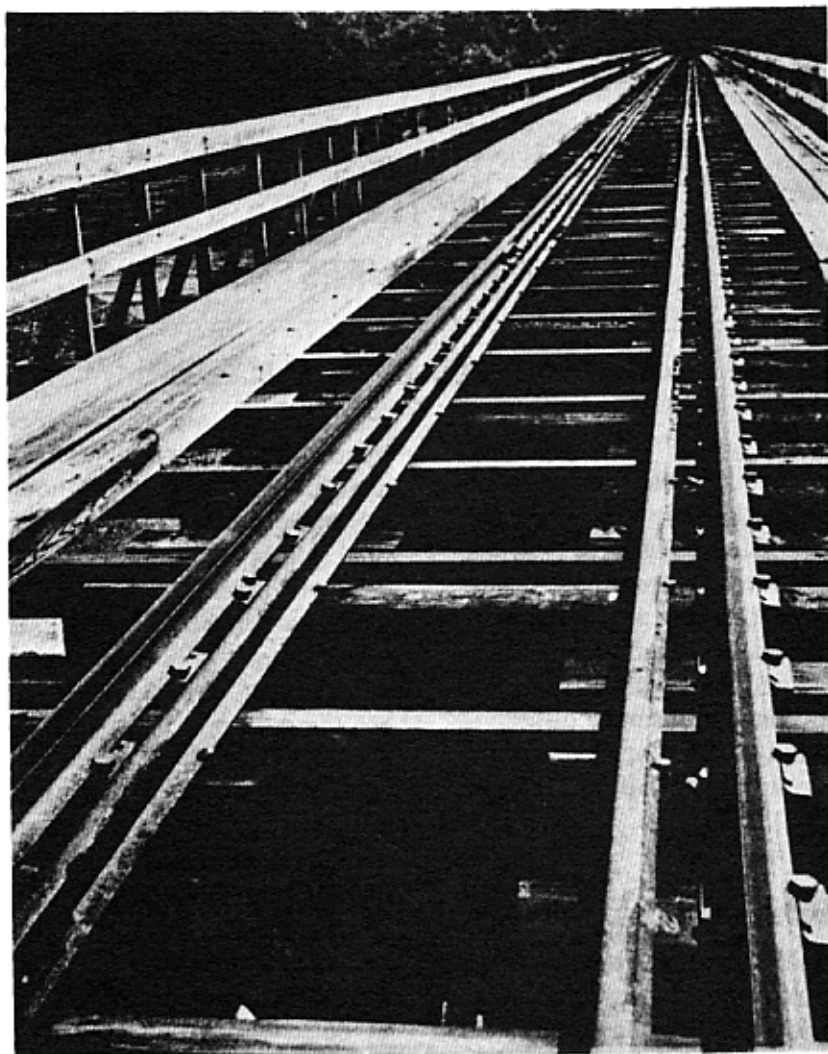


Figure 5-1. Open deck pile trestle (special).

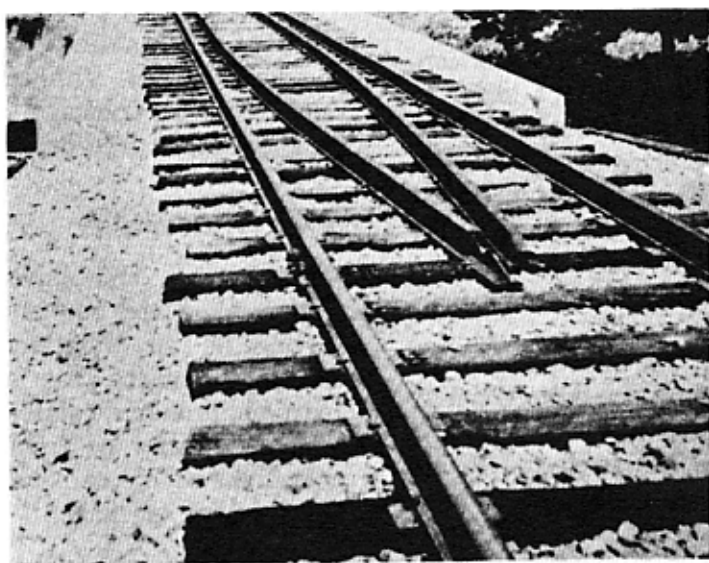


Figure 5-2. Ballast deck trackage.

tures expand, could cause stresses exceeding design capability. Bearing assemblies must be kept clean and well lubricated. Bearing assemblies and expansion joints should be lubricated and/or cleaned annually or semiannually.

5-6. Corrosion.

For those metal portions of trackage structures, the most common form of preventive maintenance is periodic painting. Effective painting requires proper preparation of the surfaces to be painted and the use of proven primers and/or paints. For metals in normal environments, a nominal cleaning with hand or power tools should provide adequate preparation for painting. Where surfaces are subject to corrosive environments (industrial or marine), abrasive blast coatings should be applied immediately to the carefully prepared and cleaned surface. The most corrosion-resistant top coating for such surface is a vinyl paint conforming to DOD Interim Specification VR-3 or VR-6. What type and how many coats to apply will depend on the condition of the existing surface and coating and on the frequency at which it is repainted. (Refer to Paints and Protective Coatings Manual TM 5-618, AFM 85-3, and MO-110.)

5-7. Structure Drainage.

Periodic inspection of the weepholes near the bases of structures will reveal those that have become plugged and ineffective. A small wrecking bar or smaller tool should be sufficient to unplug the weepholes. The following measures should be taken for weepholes that frequently become plugged. If the plugging material is earth, sand, or debris carried into the hole from behind the structure, a screen should be inserted at the rear of the weephole. To prevent plugging of the weepholes by animals or birds who enter from the front face of the structure, a screen should be placed across the front of the hole.

5-8. Concrete Structures.

The most effective preventive maintenance for concrete structures is waterproofing the surface. Both cementitious and bituminous coatings are used for this purpose. Both provide a degree of waterproofing that tends to minimize or eliminate the absorption of moisture that can result in concrete deterioration. Where color is a consideration, bituminous coatings are not used.

5-8.1. Repair of Concrete Structures. The repair of structural concrete requires careful preparation. The best concrete used for such repair will be ineffectual unless it is applied to sound, properly prepared concrete in the original structure. All deficient concrete must be removed to expose hard, strong mate-

rial. The area to be repaired must be cleaned (may require washing with acid and water) and kept clean until the application of the repair material.

5-8.2. Materials for Repairs. Concrete for repairs may be Portland cement concrete or a system of epoxy resin grout and concrete. The depth and extent of the needed repair, the environment to which the repaired structure is subjected, the required flexibility, and the time available for making the repair determine whether conventional Portland cement concrete or the epoxy system is to be used. Relatively thin concrete repairs or patches of limited extent can best be accomplished with the more expensive epoxy system. Deep repairs of large extent are usually accomplished with Portland cement concrete which, incidentally, takes longer to attain its design strength.

5-9. Trestles.

To the maximum possible degree, all wood should be prefabricated before being pressure treated. All dimensions of individual members shall be anticipated, including the locations and sizes of all holes to be drilled in each member (Figure 5-3). Rot, insects, and marine borers can be expected to attack wood where it has been cut or drilled in the field. Field-applied preservatives at such points are mandatory but are not as effective as pressure-applied preservatives. Preventive maintenance for wood structures includes periodic checking and renewal of surface-applied preservatives. Exposed cutoffs, daps, and recesses cut into piling and timber are especially vulnerable. Cutoff pile tops are frequently covered with flexible fabric or metal so as to shed rain. Timber trestles, piling, and other wood structures should be examined for soundness by boring with an auger when deterioration is suspected or when necessary to make an engineering analysis.

5-10. Undercutting.

When scour develops into undercutting of structure footings and foundations, immediate and effective corrective measures must be taken to prevent loss of the entire structure. An engineering analysis should be undertaken to determine the scope of safe and proper repair.

5-11. Structure and Approach Trackage

Adequate and effective maintenance of trackage on structures and structure approaches is as essential as the maintenance of the structures. Poor trackage maintenance can cause excessive vibration and undue stresses in structures and can result in disastrous derailments.

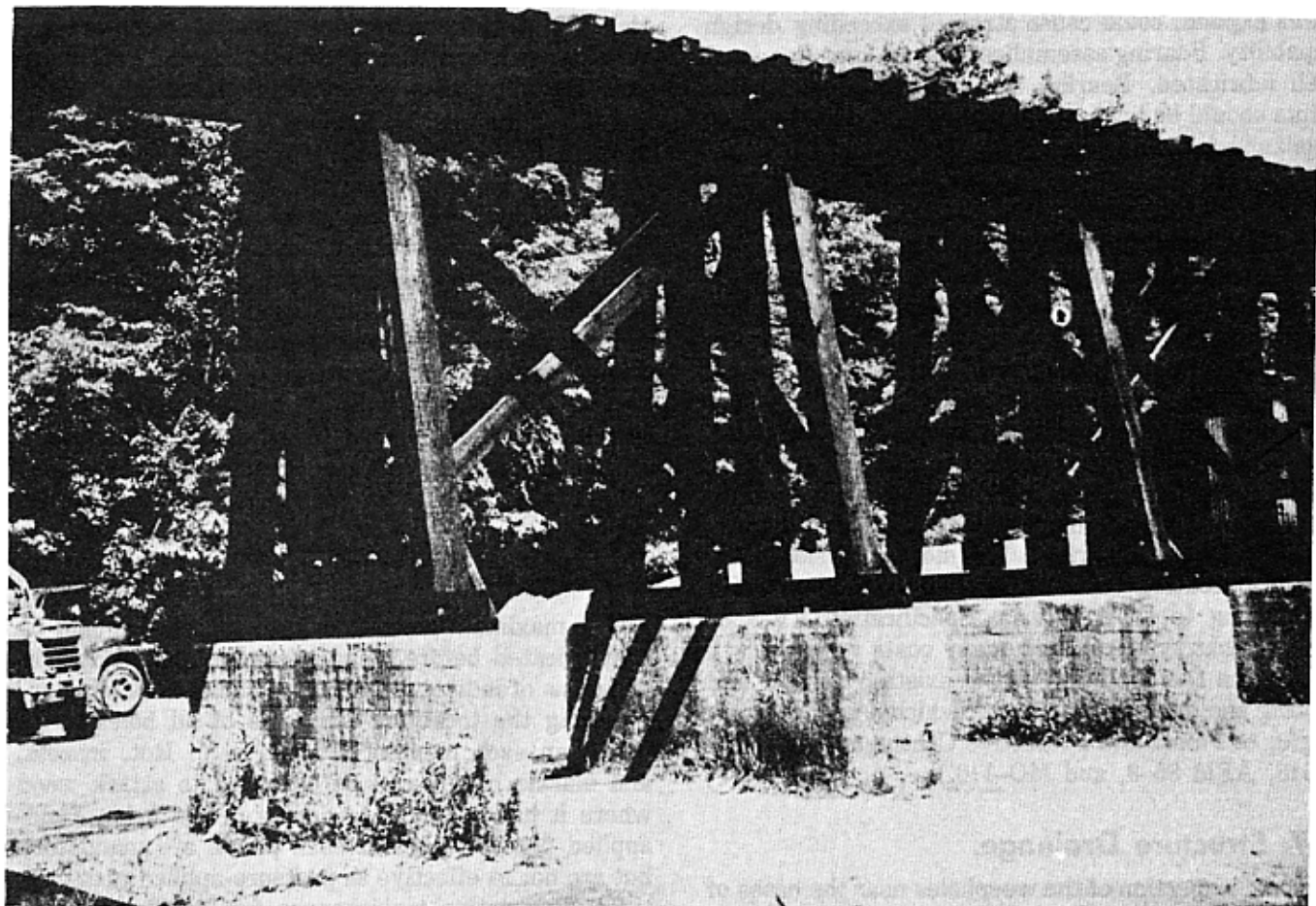


Figure 5-3. Trestle on concrete piers.

CHAPTER 6.

SAFETY

Section 1. ACCIDENT CAUSES AND SAFETY MEASURES

6-1. General.

The greatest single cause of accidents on military installation trackage is insufficient clearance for moving railroad cars and/or personnel. In many cases, minimum clearance limits are violated by building additions, stacked materials, parked vehicles, and protruding piping or wiring attached to platforms and walls. Other prominent accident causes are unsafe equipment, unstable loads, tripping hazards, lack of illumination, lack of warning devices, restricted visibility, and unauthorized crossings. Just plain carelessness is another cause of accident around the tracks and railroad cars. Hazards shall be classified by degree as required by Military Standard 822-A, System Safety Program Requirements as described in paragraphs 7-8.1 through 7-8.3.4.

6-2. Fixed Structures.

Fixed structures that impair safe clearance are listed below in the general order of prevalent hazards.

6-2.1. Platforms. Floors and elevated platforms in excess of 3 feet 9 inches in height must be a minimum of 6 feet 2 inches from the center of the track (Figure 6-1). This clearance is often lost for several reasons. Old, wood platforms may sag and lean toward the track, or timbers may become loose and bend outward from the platform. In strengthening platforms, timber should not be scabbed on to overlap the existing timbers that have deteriorated or become weakened, or other construction added that extends the platform trackwise. A reduction of the 6-foot 2-inch clearance, even by several inches, could result in an injury to a riding trainman or, if the obstruction protrudes far enough, it could strike and damage the stirrups and grab irons on the cars.

6-2.2. Retaining Walls. Retaining walls must also have a minimum clearance of 8 feet 6 inches (Figure 6-1). This minimum clearance may be lost by the wall creeping or bulging from pressures on the other side.

6-2.3. Pipes and Wires. Utilities services should not be attached to existing platforms and buildings or retaining walls having proper clearance. The pipes,

cables, and wiring affixed to brackets or fasteners that protrude from the surface to which they are attached reduce the clearance, sometimes to an unacceptable degree.

6-2.4. Buildings. Additions to existing buildings should not encroach upon the minimum clearance (8 feet 6 inches), or windows, shutters, or doors that swing outward should not be installed. The latter are particularly dangerous because they often are not noticed or may be opened as a train is passing by. It is important that structural plans as well as plans for installing outside piping and wiring be approved to assure that such hazards are not created. Window-type air conditioners should not be installed in buildings within the clearance zone, as they often protrude significantly into the area involved. Canopies and other overhanging elements must be high enough to clear locomotives and cars (Figure 6-1).

6-2.5. Gates. At many installations, trackage may pass through boundary perimeter and/or security fences. Gates should be securely fastened in open position to prevent them from swinging toward the moving train, striking the locomotive and/or cars or a riding trainman.

6-2.6. Overhead Structures. Pipe trestles, bridges, elevator bins, chutes, and other overhead structures must meet the clearance criteria on Figure 6-1. Equipment used to load or unload cars must be raised to a safe clearance prior to train movements. Suitable devices must be installed to keep this equipment in a raised position at this safe clearance not in use.

6-3. Safe Clearance Limits.

6-3.1. Parked Vehicles. Areas adjacent to railroad trackage on military installations are sometimes used for vehicle parking. Suitable bumpers or rail guards will be installed to prevent personnel from parking vehicles inside the safe clearance limit. In the loading areas, hand trucks, fork lifts, and other materials handling equipment must not be left carelessly at less than safe distances from the track.

6-3.2. Trucks. Trucks often load directly into or unload directly from the railroad cars. They must be

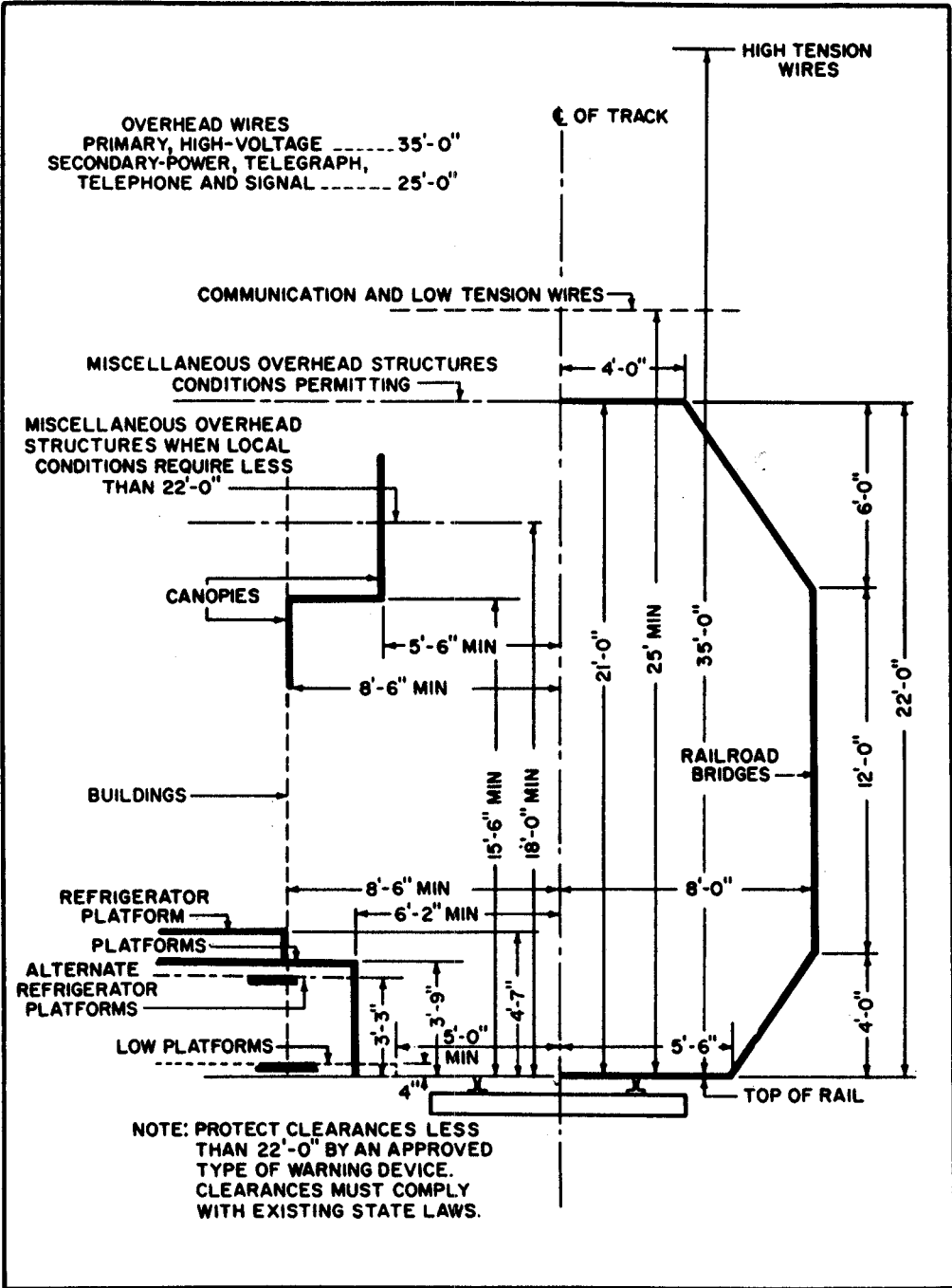


Figure 6-1. Minimum safe clearances.

moved at least 8 feet from the centerline of the track before moving the railroad cars. Trucks at loading docks in restricted areas must park so that neither the truck tractor nor the trailer encroaches on the safe clearance limits.

6-3.3. Stored Materials. Materials are often stored adjacent to railroad tracks. Palleted or stacked material must clear the track area by not less than 8 feet from the track centerline. Loose material such as sand, gravel, coal, etc., must be stored in bins or at least in an area that is barricaded on the trackward side. Coils of cable must be placed or blocked so that they cannot roll toward the track. Drums must be placed and stacked so that they will not tumble or roll toward the track. The 8-foot clearance criterion applies to short- or long-time stored materials. Flammable or explosive materials must be stored at clearances specified by the activity safety engineer, fire marshal, or ordnance officer.

6-3.4. Curves. The clearances shown in Figure 6-1 may have to be increased in the areas of switches and curves. The sharpness of the curve and the overhang of the longest cars brought into the installation will determine the increase in clearance required. The clearances shown are for tangent track and new construction. Clearances for reconstruction work or for alteration depend on existing physical conditions and, where reasonably possible, should be improved to meet the requirements for new construction. On curved track, the lateral clearances shall be increased 1 inch per degree of curvature, with a maximum increase of 18 inches. When the fixed obstruction is on tangent track but the track is curved within 80 feet of the obstruction, the lateral clearances shall be increased as follows:

Distances from Obstruction to Curved Track ft	Increase per Degree of Curvature in.
0-20	1
21-40	3/4
41-60	1/2
61-80	1/4

6-4. Other Obstacles or Hazards.

6-4.1. Track Condition. Track conditions such as broken rails, broken rail joints, rotten ties, loose spikes, and maladjusted switches can cause derailment. Procedures for correcting these conditions are outlined in Chapters 3 and 4.

6-4.2. Drainage. Lack of adequate drainage can cause a softening of the roadbed. This can lead to track settlement, which in turn can result in broken rail joints or loose spikes. Shoulder erosion creates hazardous footing, which may result in missteps or falling. Procedures for correcting drainage deficiencies are outlined in Chapter 4, Section 3, and Chapter 5, Section 2.

6-4.3. Housekeeping. Tools, track hardware, ties, rails, spillage from hopper cars (coal, gravel, etc.), trash, and refuse left along the track are serious hazards.

6-4.4. Excavations. Open trenches are hazards. Excavated earth and stone from these trenches, if left on the shoulder or at an inadequate distance from the track, add to the danger. Trenches must be marked clearly or covered with planks or gratings when work is not being done. Excavation must also be adequately shored to prevent collapsing and shifting or settling of the roadbed. Permanent pits, trenches, and other openings under or around the track must have flush-fitting gratings or covers, which will be kept in place at all times, when not in use.

6-4.5. Accessories and Devices. Accessories such as lamps, rerailers, and derailleurs must be kept in good working condition. Lamps or lights must be lit during periods of poor visibility. Crossing signals and gates, switch stands, interlocking devices, etc., must be maintained in serviceable condition to prevent accidents. Bumpers or wheel chocks must be maintained in operable condition. Only experienced personnel shall be involved in the use of rerailers.

6-4.6. Safety Operations. Any operation in which cars are moved must be accomplished with safety in mind. Maintenance personnel must stay clear of cars being pulled or poled, coupled or uncoupled, or rerailed. To minimize potential accidents, only authorized personnel will ride cars. Blind corners caused by buildings, walls, etc., must be protected by railings or barricades. Personnel should give standing cars a clear berth and must wait for a passing train to move a sufficient distance to enable them to observe the adjacent track for other train movements before proceeding across the tracks. Temporary or nonstandard road crossings shall be properly posted. Figure 6-2 is an example of good housekeeping and safety practices.

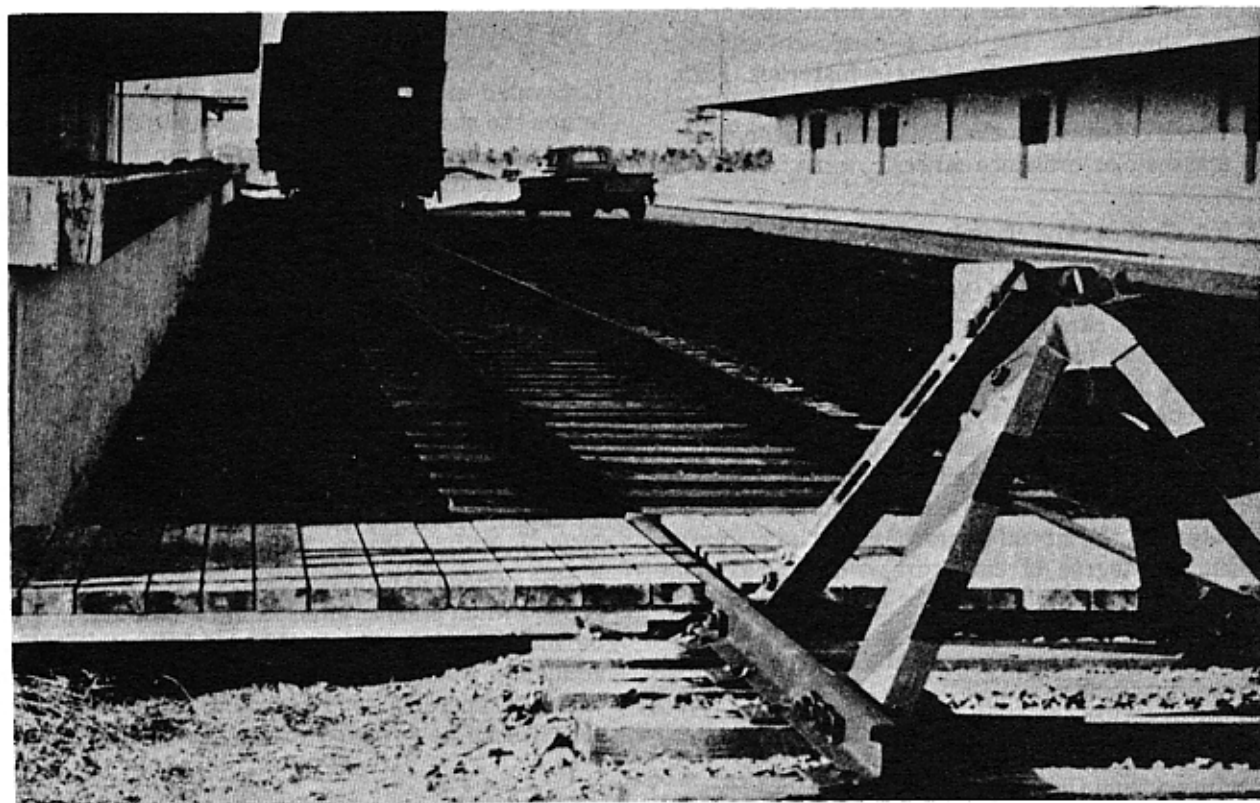


Figure 6-2. Good housekeeping and safety practice.

Section 2. SAFETY PRECAUTIONS

6-5. Procedures.

In addition to guidance concerning hazards given in the foregoing paragraphs, the following procedures must be carried out to assure maximum safety in railroad operations and maintenance.

6-5.1. Inspection. The safety inspections shall be made as directed by the installation Safety Engineer, but not less than once annually in conjunction with maintenance inspections as outlined in Chapter 7.

6-5.2. Safety Inspection Checklist. The following checklist must be used by safety inspectors, and a copy of their report shall be furnished to the installation Safety Engineer and the installation office responsible for maintenance of trackage (Chapter 1).

6-5.2.1. Clearances measured from the centerline of the track to all fixed structures. Clearances not meeting the criteria of Figure 6-1 must be reported.

6-5.2.2. Openings in all structures that have doors, windows, etc., opening out into the clearance limit.

6-5.2.3. Fixtures, pipelines, and other utilities erected or installed inside the clearance limits.

6-5.2.4. Missing or inoperative warning devices or signs. Condition of and/or obstructions of signs.

6-5.2.5. Gates that cannot be securely held open.

6-5.2.6. Unsafe condition of track shoulders or trackbed such as erosion, open ditches, trenches, or pits. Broken, loose, or missing gratings or covers.

6-5.2.7. Improperly working switches and derailers. Loss of or improper marking of clearance points.

6-5.2.8. Improper use of wheel chocks, unsafe car stationing (without set brakes or wheel chocks on grades), loose chocks and bumpers, and condition of cattle guards.

6-5.2.9. Condition of cranes, chutes, and loading or unloading devices that might affect the safe clearance criteria. This applies to all overhead structures.

6-5.2.10. Parking areas and trucks or other equipment encroaching on the clearance limits.

6-5.2.11. Materials stored an inadequate distance from track or projecting into the clearance limits from storage areas or loading docks.

6-5.2.12. Condition of rails, joints, and ties that may create a hazard.

6-5.2.13. There shall be no missing, loose, broken components, bad welds, accumulation of debris, heavy corrosion, or severe deterioration of the following trackage appurtenance: (1) ladders, platforms, and hand rails; (2) rail stops; (3) guardrails and fences; (4) crossing signs and other warning signs; and (5) any other features that could cause an accident.

6-6. Maintenance Inspectors and Track Crews.

Maintenance inspectors and/or track crews are responsible for reporting obstructions or hazards along the tracks such as trash, loose hardware, and any other objects that foul the safe clearance limits. Maintenance personnel shall remove or clean up such obstacles as they go along. More detailed responsibilities of these personnel are provided in Chapter 7.

Section 3. SAFETY WARNINGS AND SIGNS

6-7. Installation of Warnings and Signs.

When hazards exist because of inadequate clearances, construction work, blind corners or approaches, proximity of flammable or explosive storage, heavy vehicle or pedestrian traffic, crossings, and any other condition or situation that would jeopardize operations, people, or property, appropriate warning signs or signals that shall be posted or installed. Signs must be clearly visible and maintained in a legible condition. Signals must be maintained to be operable at all times. Signs may be fixed and installed at proper clearances from the track or may be portable and temporary. Signs must be standard "blue" signs or metal flags unless otherwise prescribed. Signs shall be removed when no longer required. Typical signs are STOP, DERAIL, STOP-TANK CAR CONNECTED, and DANGER-MEN WORKING.

6-8. Clearance Markings for Crossings, Turnouts, and Ladder Tracks.

Clearance markers shall be painted on rails of adjacent tracks where the minimum clearance is reduced. Chrome yellow paint shall be used. The marker shall be 12 inches long, painted on both sides of each rail at the clearance point. Figure 3-64 (para 3-31.13.) shows typical clearance markers. In paved areas, a 12- by 24-inch yellow marker shall be painted between the tracks at the clearance point.

6-9. Whistle and/or Ring (Bell) Signs.

These signs are usually shop fabricated (Figure 6-3). Whistle and ring signs are placed at the distances from the crossings as specified in applicable state or municipal requirements, or where no such requirements exist, the AREA Standards.

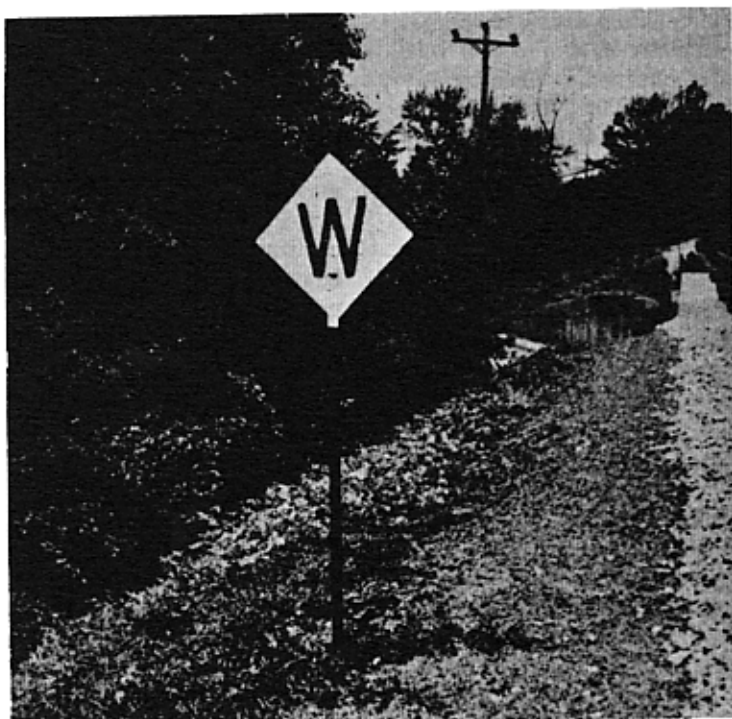


Figure 6-3. Whistle sign.

CHAPTER 7.

MAINTENANCE INSPECTION AND SERVICES

Section 1. GENERAL

7-1. Purpose.

Chapters 1 through 6 of this manual describe procedures for effectively maintaining trackage systems at military installations. The planning and developing of an effective track maintenance program must be based on thorough and timely track inspections by competent inspectors. This chapter describes procedures for inspecting trackage systems and systematically detecting, identifying, and reporting deficiencies and trouble areas within those systems. Inspection criteria shall be formulated by the ruling activity based on but not necessarily limited to the standards shown in Appendix B.

7-2. Responsibility.

Providing qualified trackage inspection at each military installation is the responsibility of the department tasked with the maintenance of the trackage and other real property as shown in Chapter 1. In making inspection, as in performing maintenance and repair work, the safety precautions of Chapters 1 and 6 of this manual must be observed.

7-3. Inspection of Railroad and Crane Trackage.

Railroad and crane trackage inspections shall be performed at the frequencies and in the detail specified by agency policy. In general, inspections shall consist of observing and functioning of the trackage as related to safety, maintenance, and design parameters. Examination will be by sight, sound, feel, instrumentation, and nondestructive testing. Inspection of trackage includes rails, ties, subgrade, supports, foundations, drainage appendages, and accessories. Primary emphasis shall be given to insuring maximum safety by maintaining all facilities in a safe and sound condition. Deviations from the standards set forth herein shall be approved by waiver from the appropriate service (see Chapter 1).

7-3.1. Preparation. Prior to the investigation of a segment of crane or railroad trackage the inspector

shall become familiar with as many available factors of the operation as possible. All pertinent information and data available should be reviewed. These may include results of previous investigations, statistical information on safety performance, and causal factors of accidents determined in accident investigations. Omission, deletion, or uncorrected defects noted on these previous reports give clues to the inspector on locations where detailed investigations may be required. In addition, to save time and facilitate a more complete investigation, as well as to gain the cooperation of the activity, the following preparations should be made: (1) notify the personnel responsible for the track and those responsible for operations over the track in the territory to be inspected, and (2) set a date and location for the start of the inspection. If time permits, secure the following information from the activity in advance of the investigation:

7-3.1.1. Timetables and special instructions covering territory to be inspected, showing method of operation, maximum allowable speeds, permanent speed restrictions, equipment, and loading restrictions.

7-3.1.2. Trains or cranes per day in each direction, average tonnage, and amount of hazardous materials movement.

7-3.1.3. Locations, speeds, and reason for existing temporary slow orders.

7-3.2. Inspection.

7-3.2.1. Duties of Inspector. The inspector's primary duty is to conduct effective investigations to determine whether the crane or railroad trackage is complying with the safety standards and regulations. Effective investigation requires identification, professional evaluation, and accurate reporting of safety conditions and practices. Inspections may vary considerably in scope and detail, depending upon the circumstances in each case.

7-3.2.2. Records. The examination of records, of track components, and the measurement of track geometry for the determination of compliance with requirements are the responsibility of the inspector.

7-3.2.3. Personal Safety. The inspector's first concern is his own personal safety, as well as the safety of any personnel accompanying him. He will make sure he has current lineup of all train, crane, or other equipment movement and has permission to occupy designated tracks between designated times. When afoot on the railroad track, he must always be alert, expect a train on any track at any time in either direction, and be prepared to promptly clear such train. Extra personal care must be exercised under adverse weather conditions.

7-3.2.4. Safety Rules. The inspectors should know and comply with the safety rules of the installation. They will also wear the safety equipment specified by the activity.

7-3.3. Advanced Notice of Investigation.

7-3.3.1. Schedules Inspection. Since the efficiency and safety of an inspection can be significantly improved by the assistance of operating personnel, advance notice of investigation will be given in all cases where feasible. The inspectors should give ample notice of the territory to be investigated, a proposed date for starting this investigation and an

invitation to have a representative of the activity accompany them on the investigation. The activities representative should have immediate knowledge of all conditions noted by previous inspections and can assist in providing accurate locations or distances to named locations and furnish proper track designations.

7-3.3.2. Time Frame. Sufficient time should be provided in planning an investigation to allow activity representatives to prepare themselves and/or permit reasonable adjustments to be made in the schedule.

7-3.3.3. Unscheduled Inspection. These instructions, however, are not to be construed to prohibit unaccompanied investigations when other activity personnel are unavailable to furnish assistance.

7-3.4. Inspection Equipment and Tools. In order to make a proper track inspection, certain tools and equipment are necessary. The basic equipment needed is a track level and gage, a frog gage for rigid frogs, a hammer for sounding rail in paved areas, a rule, a cord 62 feet long, report forms, and a copy of this manual.

Section 2. INSPECTION AND REPORTING

7-4. Categories of Inspection.

7-4.1. Continuous Operator Inspection. Daily or prior to use, safety checks listed in activity regulations shall be conducted. In addition, on-the-job observations shall be going on at all times when equipment is working. Crane and railroad operations personnel (operators, engineers, trackmen, riggers, etc.) shall be encouraged to observe and report track problems, deficiencies, obstructions, and the "feel" of the track. When walking down the track, the inspector/operator can look for broken rails and other rail defects, faulty switch-point closures, indications of wide gauge, poor line or surface, loose crossing planks, wheel flanges striking frog points, working spikes and joints, pull-aparts, evidence of the imminence of track buckling, scour at bridges, and the threat of slides. All these things can contribute to train accidents and should be brought to the attention of the responsible person for correction.

7-4.2. Preventive Maintenance Inspection. Preventive maintenance (PM) inspection is a visual, continuous routine (shop level) working-inspection. It is performed in conjunction with daily assigned maintenance and repair tasks. *When possible, deficiencies are corrected during the inspection and no record made.* Uncorrected deficiencies shall be reported to the supervisor for action, inclusion in the repair work schedule, adjustment of operating speed, and/or closure of section of trackage.

7-4.2.1. The PM inspection is designed to detect and correct those trackage deficiencies that develop from day to day. If the track walker can correct an observed deficiency in a half-hour or less, it should be done; if not, it must be reported. From these reports, the essential trackage maintenance and repair work schedules are developed and implemented.

7-4.2.2. The types of deficiencies PM inspection is designed to detect, and which the track walker may be able to correct include but are not limited to: insufficient switch lubrication; shortage of or lack of fuel and untrimmed wicks in lighted switch targets; loose or missing joint bolts, rail spikes, plates, or anchors; condition of derails and wheel locks; ice or debris-fouling switches and flangeways in paved areas; defective bumper blocks; and poor housekeeping (para 6-4). Uncorrected items may include but are not limited to: broken ties, defective switch points, inoperative switches, operator reported rough or soft spots, poor drainage, substructure failure, defective rail, settlement, condition of supporting columns, and misalignment. The most important sections to be checked are the switches, curves, and any area where a derailment has occurred.

7-4.3. Overall Track Inspection. Because overall track inspections of trackage are more inclusive and exacting than the PM inspections, only qualified personnel should be assigned to make them. Annual inspections are required except where snow, ice, and

subfreezing temperatures or unusual climatic conditions are an important factor. In these circumstances overall track inspections should be scheduled more frequently. Where winters are a significant maintenance factor, one overall track inspection is scheduled in the early fall or late summer and one soon after the spring thaws. Reports of overall track inspections are used: (1) to plan the immediate work needed to prepare for and to recover from the effects of winter; (2) to determine if a condition exists that requires engineering investigation, additional testing, or evaluation; (3) to develop the several annual reports of trackage work and the single or multiyear maintenance plans required; and (4) as the basis of Backlog of Maintenance Reports.

7-4.3.1. **Methods of Detection.** Overall track inspections should include all checks performed during the PM inspections plus all other detectable deficiencies. Visual inspections should include observations of all readily accessible components of the trackage system including rails, ties, rail accessories, switches, crossovers, ballast roadbeds, support structures, and appurtenances. Basic checkpoints for trackage inspection are listed in Chapter 6 and Appendix B. Using the inspection reports and relating them to the installation's basic trackage requirements, its in-house capabilities, priorities, available funding, and other factors, the annual and the long-range trackage maintenance and repair programs are developed and programmed. Also, these reports can be a factor in the development of future trackage programs. Since all rail flaws are not visible to the eye, rail inspection that will detect internal flaws is significant (para 3-14 and 7-5) to an overall track inspection. The detection of internal rail flaws by a detector car has been standard practice on American railroads for a number of years. These cars use both the induction and ultrasonic methods. The cars are available by contract on an hourly rental basis. An overall track inspection report of running track cannot be completely comprehensive without the inclusion of a report showing the results of nondestructive rail tests.

7-4.3.2. **Checklists and Reporting.** Provide overall track inspectors with checklists that include, but are not necessarily limited to, all the types of deficiencies included in paragraph 6-5.2 and Appendix B. The inspectors will report in detail the condition of all the trackage and track elements. Their reports will recommend the priority(s) of work and the best method(s) of correcting reported deficiencies. Exceptionally complex and/or unusual trackage maintenance/repair problems may have to be subjected to in-depth engineering review for best resolution.

7-4.3.3. **Classification of Hazards.** Inspectors should designate the degree of hazard (negligible,

marginal, critical, or catastrophic, see para 7-8.1) as required by the reference in Chapter 6 based on their judgment. Where there is a doubt regarding the seriousness of a defect, or a questionable safety condition, use shall be stopped over the section of trackage involved until the deficiencies are corrected or until safe use has been determined. Deficiencies designated as critical or catastrophic by inspection personnel shall be evaluated by the cognizant engineering or maintenance organization to determine corrective action and interim precautionary measures including use-restrictions.

7-4.3.4. **Support Structures.** All subgrades, ballast, foundations, and bridges or trestles shall be inspected for signs of settlement or failure. Special attention should be given to looking for openings in quaywalls, bulkheads, or other waterfront retaining structures that may permit fill material to wash out and cause trackage settlement and failure. Buildings supporting elevated cranes shall be inspected in accordance with designated criteria.

7-4.3.5. **Paved Areas.** In asphalt, concrete, or grouted areas visual inspection shall include observations for exposed rail defects, trackage movements exceeding the limits stated herein, and signs of distress in adjacent pavement. Potentially serious defects or suspected failures shall be cause for removal of paving and a detailed investigation of trackage. Pavement shall be maintained so that it does not interfere with railroad or crane operation and to insure safe vehicle movement.

7-4.3.6. **Measurements.** Visual observations or spot-check measurements shall be made of—grade, track gage, cross-section elevation, curve radius, horizontal alignment, vertical mismatch, supports, and other features to insure that appropriate criteria are met. Instrument surveys may be requested by the inspector to verify visual observations or spot-check measurements, establish new alignment, investigate problem areas, and/or determine deviation from the established standards.

7-4.3.7. **Track Geometry.** Horizontal alignment, grade, cross-section elevation, and/or gage shall be investigated when any of the following conditions exist:

7-4.3.7.1. There are indications of abnormal wear on the railheads or on wheel flanges.

7-4.3.7.2. New rails are being installed or any portion of a rail is realigned.

7-4.3.7.3. Operating crane or railroad engine bind have difficulty in starting or have trouble with movement.

7-4.3.7.4. When a potential deficiency of trackage can be observed, heard, or felt.

7-4.3.7.5. There are indications of substructure settlement, failure, or other structural changes.

7-4.3.7.6. Visual observations indicate that the acceptable limits may exceed those limits established by the activity.

7-4.3.7.7. Tests, inspection, experience, or engineering judgment indicate operation or rail alignment problems.

7-4.4. Optional Operational Observations. An operational observation is the observation of engine, crane or car working on the trackage system. The purpose of an operational inspection is to assist in the identification of problem areas which could develop into unsafe trackage. Conditions which may be discovered include the following: (1) soft spots in the ballast; (2) weak or disintegrated ties; (3) looseness, binding, or vibration; and (4) from our off-track, generally down-grade, position we can look for "daylight" under wheel treads and other evidence of wheels trying to climb the rails, as well as for dragging equipment.

7-4.4.1. Frequency. Operational inspections on active trackage systems shall be performed at irregular intervals to insure that the trackage systems will sustain the prescribed load in a safe manner. Railroad sidings, storage trackage, and sections of crane or railroad trackage blocked or seldom used should have operational inspections within a maximum interval of five years. However, visual observation of trackage during routine traffic loading after repair and during investigations is recommended. Low-use trackage serving hazardous loads such as ordnance or fuel shall have an operational inspection within 2 years prior to use.

7-4.4.2. Routine Traffic Observations. Trackage shall be inspected while equipment is operating. Observations for looseness, binding, deflection, or vibration shall be made by sight, sound, and feel. In addition, rail joints, ties, tie plates, ballast or grout, general alignment, rail condition, supporting structures, and other accessories may be observed for deficiencies during operational inspection. Observations may be made (1) during routine annual inspections, (2) by operators in conjunction with daily safety checks, (3) by maintenance-of-way supervisor from the lead car or engine, or (4) by inspectors adjacent to the trackage. When the operational inspection is performed onboard a train or engine, supplemental observations of passing rail traffic at randomly selected and suspected defective areas shall be made. There is no requirement for physical measurements of rail or trackage systems under load; however, when practical and accessible, rail systems shall be observed for deflection. Guidelines for maximum allowable deflections as established by the inspection shall be determined by visual judgment. In the event unusual movement is observed or felt, deflections appear to be larger than the guideline limits established, or the cause of deficiency cannot be immedi-

ately determined, an investigation and engineering analysis of the immediate vicinity shall be made prior to determining the degree of hazard. Results of the investigation and engineering analysis, not the deflection limit per se, shall determine when use of a section of trackage must be discontinued.

7-4.4.3. Loads. Loads defined below should be moved over track systems slowly enough so that observations can be made.

7-4.4.3.1. Railroad Trackage. Loads on rails shall be provided by routine rail traffic that normally operates on the track. If a typical train is not observed, the load on the rail may be provided by a locomotive, engine, or test car. When a test car is used, it shall be loaded to give the maximum anticipated load on at least one axle and as close to the total anticipated load as practical.

7-4.4.3.2. Ground-Level Crane Trackage. The operational inspection shall be conducted by using the heaviest crane or the crane with the largest wheel load that can operate on the track. **NOTE:** The inspection may be conducted with no load on the hook and with the boom parallel to the track.

7-4.4.3.3. Elevated Crane Trackage. Elevated crane trackage systems shall be inspected after completion of each crane load test. Sections of elevated crane rail trackage not observed during crane load tests shall be observed during the operation of the heaviest crane that can operate on the track with no load on the hook and the trolley positioned adjacent to the rail being observed.

7-4.5. Interim (Emergency) Inspections. Trackage is often damaged during severe weather. Interim inspections must be made during or immediately following heavy rain, ice, and/or windstorms and extremely high tides or waves. Damage that affects operation safety will be reported immediately.

7-5. Nondestructive Testing.

It is recommended that all active ground-level crane, elevated crane, and railroad rails be tested nondestructively for defects at 5-year intervals, unless maintenance problems or visual inspection dictate a necessity for more frequent testing. Illustrations of defects and criteria for unacceptable rails are included in Chapter 3 and Appendix B. New rail and accessories shall be accepted according to the latest Government specification and/or standard industry practice. The nondestructive test results shall be used to establish a baseline for future inspection and to identify areas requiring observation. Nondestructive testing of new, stockpiled, or relay (used) rail put into service, may be deferred until the next regularly scheduled test at the discretion of the commanding officer. During the interim period, the rail may be

given a safety-use rating based on other tests, observations, and inspections recommended by this manual.

7-5.1. Sounding. Sounding with a hammer is one of the best and least expensive methods of testing rail, and is a practical way to inspect relatively short sections of trackage, elevated crane trackage, and other trackage systems where ultrasonic testing is impractical. Light tapping with a small hammer about every 6 inches will reveal looseness between the rail and anchor plate, and defects before they become serious. Similar to ultrasonic testing, all nonstandard responses should be investigated and recorded for future comparison. This system may be used to test rail when electronic inspection is impractical. However, depending on rail usage, age, history, and experience, the activity should consider using an inspection schedule shorter than the programmed 5-year interval when using sounding as the nondestructive method.

7-5.2. Ultrasonic Testing. Ultrasonic inspection is a nondestructive test method for revealing internal discontinuities in dense homogenous materials by means of acoustic waves of frequencies above the audible range. Ultrasonic testing is the preferred method for nondestructive testing of readily accessible rail. Sonic testing devices, which are available locally or those which are available from commercial sources, can be used for this purpose. Ultrasonic testing is an economical method of checking long lengths of trackage and rail encased in pavement. Ultrasonic testing of new rail may be deferred until the next regularly scheduled 5-year test interval.

7-5.2.1. Calibration. Ultrasonic inspection equipment shall be calibrated to insure reliable interpretation of responses. The approximate smallest defects that can be consistently detected include, but are not necessarily limited to, the following simulated, "not-serious" defects: (1) a 1/4-inch-diameter hole drilled horizontally through the railhead; (2) a bolt hole through the web; (3) a horizontal 1/2-inch-long sawn crack between the head and the web; and (4) a vertical 1/2-inch-long sawn crack in the web.

7-5.2.2. Test Results. All discontinuities shall be reported, the nature and size of defect estimated, and responses compared with standards or past test results. Rejection or degree of hazard of all potential defects shall be based on assessment of ultrasonic inspection results, visual inspection, experience, engineering judgment, and the criteria established by the activity. In-place welded joints, welded repairs, and rail castings, such as frogs and certain types of switches, may have confused or erratic responses when ultrasonically tested; therefore, interpretation requires experience and/or engineering judgment to preclude an erroneous classification of defect.

7-5.3. Other Nondestructive Tests. Magnetic particle (MIL STD 271), dye penetrant, and other nondestructive test methods have limited capability for surface inspections; However, they may be advantageous in investigating potential defects indicated by other inspections. Eddy current or other approved, nondestructive test methods brought about by state-of-the-art advances may be used to supplement or replace sounding or ultrasonic testing based on local conditions, availability, economics, experience, and/or engineering judgment.

7-6. Miscellaneous Inspections and Tests.

Other inspections may be used to determine the safe condition of trackage under unique or unusual circumstances or to make a detailed engineering investigation of specific, critical components of a trackage system. The inspections performed and the frequency shall be those considered necessary by the activity or as recommended by the audit. Prior to use, the availability, limitations, and practicability of any special investigation shall be evaluated. Special inspections, such as the following, may assist in determining the condition of trackage:

7-6.1. Building Inspection. Review comments made by the building/structural inspector to verify that work affecting trackage has been scheduled.

7-6.2. Underwater Damage Assessment Television System. Divers or the Underwater Damage Assessment Television System may be required to conduct underwater inspections of waterfront containment structures (bulkheads) and dock pilings supporting trackage.

7-6.3. Seismograph. Under certain conditions seismographic instruments may be beneficial in determining voids in fill material or embankments, level of water tables, or location of slippage planes in the foundation below trackage systems.

7-6.4. Strain Gages. When the structural analysis for the anticipated maximum loading of a structure indicates certain members may be overstressed or marginal, a load test (duplicating or exceeding maximum total moment and shear experienced in-service) with stress and strain instrumentation is appropriate.

7-7. Track Records.

Up-to-date records of all trackage at each military installation are basic to the administration of trackage maintenance and repair programs. As in every type of inspection, the thoroughness with which trackage inspections are made is important. Of equal importance is the accuracy and thoroughness with which the inspection reports are prepared. Deficiencies in track elements such as switches, bridges, culverts, and road crossings will be identified and reported.

Deficiencies in hard to identify elements such as individual ties, joints, and rails will be summarized in the reports. Field identification of those deficiencies will be accomplished by durable markings; for example, each tie to be replaced is indicated by inspector-applied markings. (See Figures 3-20 and 3-21 in paragraph 3-11.3.) In order to manage and administer trackage inspections, maintenance programs, and design, the following information should be available in a usable condition so that it may be referred to easily and readily. Where documents do not exist, a long-range program should be established to obtain the appropriate information for retention in activity files.

7-7.1. Inspection Reports. Inspection reports should be filed and maintained in accordance with current directives. If track charts (Appendix E, Figure E-1) are used, the inspection report form should reference a track chart. Each inspection report should record the inspection findings of only a specific segment of track. When track charts are used, only that track shown on the referenced track chart should be reported. Where more detailed reports are required than can be shown in the limited space provided in the inspection report form, the form may be supplemented with photographs and other supporting material. Until reported deficiencies have been corrected, it is essential that the reports and appropriate supporting material be conveniently accessible, in accordance with current directives. The current degree of hazard for each section of trackage shall be shown on the track chart, map, or other prominent document.

7-7.2. Track Charts. Track charts, although not required by all departments, are a useful tool in scheduling maintenance and repair work and for indicating areas of important track elements that require other than the usual amount of maintenance and repair. Track charts or plans should be maintained as part of the real property records. The charts or plans shall be kept up to date and used for programming future work, scheduling current work, indicating abnormal conditions, and recording maintenance and inspection data. Charts or plans can be in any format and shall be usable as a working document. Curve data shall be recorded for all curves.

7-7.3. Plan and Profile. Detailed plan and top of rail profile or grades of crane and railroad track systems should be kept current and may be shown on the track chart or separately. Size and type of rail, switches, degree of curve, frogs, and other rail appurtenances should be indicated on the plan. Reference points for location and elevation checks should be accurately referenced.

7-7.4. Cross Section. Cross sections of substructures shall be maintained, when known and available,

especially the investigation reports of substructures under crane or railroad tracks around piers, dry-docks, trestles, wet areas, and the major supporting substructures of elevated cranes.

7-7.5. Historical Data. Historical data on each system shall be retained or developed and include the following: (1) dates that the system was installed; (2) weight of rail, gage of track; (3) history of maintenance and repair; (4) replacement of rail; (5) methods of accomplishing previous work; (6) general overall trackage condition; (7) maximum capacity; (8) original intent or use of trackage; (9) engineering calculations to establish maximum loading; (10) HQ approval of railroad curves with radii less than 300 feet; (11) justification of exceptions to standards, waivers; (12) valid structural analysis for all supporting structures based on or exceeding current maximum loading; and (13) other pertinent information.

7-7.6. Proposed Projects. Maintain a list of pending work including: (1) major repair projects (approved, submitted, and needed), (2) minor work to be accomplished with local funding, and (3) major replacement projects which are being considered for MCON funding. Use "multiyear" renewal program for rail replacement when practical.

7-7.7. PM Inspection Reports. Local formats in existence may be used. As a minimum, PM inspection reports should include: (1) date, (2) sections of trackage inspected, (3) unrepaired deficiencies, (4) number of and size of broken or missing parts, (5) suspected misalignment or defect, and (6) guides and instructions used for the inspection. The current PM inspection report and the one for the preceding period shall be retained. Work authorization documents or shop repair orders, usually the action following PM inspections, shall be kept for 5 years.

7-7.8. Overall Track Inspection. As a minimum, activity track files shall contain the latest complete control inspection report, supplemental engineering inspection reports, and all engineering investigation reports made since the last complete annual or special report. Modification and alteration approvals including engineering investigations and field checks shall be kept for 5 years. Current operational inspection records shall be kept until superseded.

7-7.9. Nondestructive Testing. Current nondestructive test records shall be kept on file for all rails. Data collected from the ultrasonic or induction tests shall be retained as necessary for baseline and defect growth comparisons. A narrative report should be included to explain any unusual observations.

7-7.10. Program Review Report. The program review, HQ/command assistance, or IG inspection report and activity responses shall be retained until superseded.

7-8. Inspection Check Points.

The types of deficiencies inspectors are required to note are described in Chapters 1 through 5 and Appendix B of this manual. The day-to-day deficiencies PM inspectors are expected to note are relatively few in number, and all are quite simple to detect. They are mentioned in paragraph 7-4.2. Engineering inspections and interim inspections should note and report all the types of deficiencies covered by PM inspections, plus all of the other shortcomings of trackage that are described in Chapters 1 through 5 and Appendix B of this manual. Careful visual inspections can detect many of the shortcomings; others are more complex and can be detected only by certain techniques.

7-8.1. Degree of Hazard. A *hazard* is any real or potential condition that can cause injury or death to personnel, or damage to or loss of equipment or property. All trackage should be classified according to one of the four categories shown below. Certification shall be made on sections of trackage at intervals not to exceed 2 years. Overall track inspections (para 7-4.3) shall be used as the basis for determining the degree of hazard. Tests of inspections made between overall track inspections that indicate previously unreported critical or catastrophic defects or other unsafe conditions shall automatically cancel the existing degree of hazard over the specific section of trackage involved. For inactive trackage or trackage used infrequently, the inspection and hazard level determination may be performed just prior to use. When there is any doubt as to the degree of hazard over a given section of trackage, the degree of hazard shall not be made until a detailed investigation and engineering evaluation has been completed to determine whether or not the section of trackage involved can be certified safe or whether or not restricted operations may continue pending repair.

7-8.2. Hazard Level Category. Hazard level is a qualitative measure of hazards stated in relative terms. For purposes of this standard, the following categories of hazard levels are defined and established: personnel error, environment, design characteristics, procedural deficiencies, or subsystem or component failure or malfunction (para 6-1 and MIL-STD-882A).

Category	Hazard Level
Negligible	Will not result in personnel injury or system damage. Minor defects that will not affect operation over trackage systems.
Marginal	Can be counteracted or controlled without injury to personnel or major system damage. Routine main-

Category	Hazard Level
Critical	tenance and repairs should be scheduled. Will cause personnel injury or major system damage, or will require immediate corrective action for personnel or system survival. Operation over trackage systems must be restricted.
Catastrophic	Will cause death or severe injury to personnel, or system loss. Operation over trackage systems shall be stopped.

7-8.3. Defect Classification. The basic rule of thumb or general guideline for determining a critical hazard of a defective rail and continuing use at DOD installations is 1/4 inch of alignment or movement. All irregularities in top or side rail wear, difference in elevation at breaks or joints, deflections, and movements exceeding 1/4 inch should be investigated. Common rail defects are illustrated in Figure 3-27. Defects are listed in the hazard category in which they normally occur. Exceptions and variations are expected; therefore, experience and/or engineering judgment must be used to determine the degree of hazard for each defect. General guidelines to assist inspectors and engineering investigators in determining the degree of hazard of a defect are described below.

7-8.3.1. Negligible. Deficiencies that are negligible are those which do not affect the safety of operation, such as:

7-8.3.1.1. Defects, such as breaks, fractures, or defective welds, corrected by the application of fully bolted angle bars.

7-8.3.1.2. Damaged rail with temporary repair (complete weld repairs are considered nondefective).

7-8.3.1.3. Weld irregularities.

7-8.3.1.4. Minor mill or mechanical defects.

7-8.3.1.5. Surface scratches or cracks.

7-8.3.1.6. Possible defects on portions of rail systems made from casting, such as frogs and certain types of switches, having confused or erratic readings when ultrasonically tested.

7-8.3.1.7. Other small defects based on activities' investigation, engineering judgment, and/or experience.

7-8.3.2. Marginal. Trackage systems with small defects such as missing nuts, loose spikes, etc., less than specified in Appendix B, shall be repaired, when possible, during regularly scheduled track work operations. Records of unrepaired rail defects and substandard trackage shall be kept current and the trackage continually observed during all future in-

spections to identify any further degradation which might result in defects.

7-8.3.3. Critical. Trackage with critical defects may continue in use provided the operating speed over the defective section is reduced and the defect or defects are carefully inspected at intervals of not more than every 6 months or as prescribed in Appendix B. Trackage systems with critical defects may be scheduled for restricted operation at the discretion of the officer in charge provided all of the following actions are taken:

7-8.3.3.1. Replacement or repair is scheduled.

7-8.3.3.2. Deficient areas are clearly and specifically marked with warning signs when practical, or specified in written instructions and restrictions.

7-8.3.3.3. Operators are informed to proceed with extreme caution.

7-8.3.3.4. Reduced speed operation is approved following an engineering inspection.

7-8.3.3.5. Additional PM inspections or checks of the defect are scheduled. (For infrequently used trackage, inspections may be made just prior to use.)

7-8.3.4. Catastrophic. Sections of trackage with catastrophic defects involved shall not be used until repaired, except as noted below. Serious trackage defects include conditions which engineering judgment and experience have determined to be unsafe, and (Appendix B) requiring immediate change out of rail. NOTE: Temporary or emergency repair of defective rails may reduce the degree of hazard to critical or marginal depending on the severity of the defect, for example see paragraph 7-8.3.1 above, items a and b. On trackage systems which have catastrophic rail defects or on dangerous or unsafe sections of trackage, general usage shall be stopped until the section(s) of trackage have been repaired or replaced. Sections of trackage that are defective, damaged, misaligned, or otherwise failing to meet the lowest standards established in Appendix B of this manual shall be barricaded or marked with warning signs (when practical) and service discontinued. When necessary to use trackage in the catastrophic category, the officer in charge shall be responsible for safety and visually supervise each operation over the defective sections.